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EDITORIAL NOTES.

THE Editor ventures again to appeal to contributors to the Geological Magazine not to send MSS. of original papers so as to arrive at the usual holiday seasons, that is around Christmas and Easter and from the middle of August till the end of September. At such dates the Editor is always away from Cambridge, and as the Magazine has no office or staff, all correspondence has to be forwarded, thus occasioning unnecessary risk of loss, besides further trouble and expense in transporting bulky parcels back to Cambridge. It would also be a great convenience if parcels which are not urgent could be clearly marked "Not to be forwarded", as a guide to the College officials who have to decide what to send on during the Editor's absence.

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In view of the fact that in the year 1933 the Edinburgh Geological Society will have completed one hundred years of work, the Council has decided that this Centenary should not be allowed to pass without endeavouring to establish some permanent memorial. A committee elected to consider the matter pointed out that the most important function of the Society is the recording of discoveries and researches in geology, and that this function is seriously handicapped by the present high cost of printing, particularly as the annual subscription to the Society has not been raised above the pre-war figure. Accordingly, it recommended that a fund should be raised, the capital sum of which should be invested and the interest used to assist in the annual publication of *Transactions*. Further, in order to mark the occasion and show appreciation of a late Fellow whose reputation is world-wide, it recommended that the fund should be called "The Peach Memorial Fund".

The Council aims at raising £1,000, and appeals to the generosity of its members and of geologists in general, confident that the response will result in such a sum as will materially assist in maintaining the prestige and utility of the Edinburgh Geological Society. Already promises of annual subscriptions have been received, including one of £25 for four years.

Subscriptions to this fund will be welcomed, and should be sent to the Honorary Treasurer, Edinburgh Geological Society, Synod Hall, Edinburgh. These will be invested at once, and the interest accruing will be devoted to meeting the costs of publication from now onwards.

ORIGINAL ARTICLES.

An Upper Carboniferous Fauna from the Amotape Mountains, North-Western Peru.

By H. Dighton Thomas, M.A. (Cantab.), Sedgwick Museum, Cambridge.

(PLATE V.)

As reported in the Geological Magazine, Vol. LX, 1923, p. 432, fossiliferous Carboniferous rocks were discovered by Messrs. C. Barrington Brown and R. A. Baldry in the Amotape Mountains of North-Western Peru, and their collection (comprising Cephalopoda, Lamellibranchia, Gasteropoda, Brachiopoda, Polyzoa, Crinoidea, etc.) presented to the Sedgwick Museum, Cambridge. This was augmented in 1924 by the presentation of a further collection made during a new visit to the area. In addition to the kindness of the two field investigators in allowing this fauna to be examined by the author, the latter wishes to acknowledge his indebtedness to Mr. C. Barrington Brown for drawing most of the figures.

Of the Carboniferous sediments [1] of the Amotape Mountains the fossiliferous rocks are all slaty, and, lying in the crush belt of the Andes, have suffered much compression. Distortion of most of the fossils has resulted, and in general little of the shell material is preserved; frequently replacement by a limonitic oxide occurs, though often the organisms are represented by casts and moulds.

A notable feature of the fauna is the abundance of the Mollusca, especially the presence of the Cephalopoda, both Ammonoidea and Nautiloidea—no Carboniferous Ammonoidea have previously been reported from South America. D'Orbigny [2] first described and figured Carboniferous fossils from South America from occurrences in Bolivia. Subsequently a small number of papers dealing with the Upper Carboniferous of that continent has appeared, but apart from short references by Bosworth [3] and Bravo [4] none deals with North-Western Peru. The Bolivian, or Bolivian and South Peruvian, faunas have been described by d'Orbigny, Salter,[5] Toula,[6] Gabb,[7]

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[1] A paper on the field occurrence of the Carboniferous rocks of the Amotape Mountains, together with a map of the area, will be published later by Mr. C. Barrington Brown.

[2] A. d'Orbigny, *Voyage dans l'Amérique méridionale*, t. iii, 1842, Paris and Strassburg.

[3] T. O. Bosworth, *Geology and Palaeontology of North-West Peru*, London, 1922, p. 322.

[4] J. J. Bravo, *Archivos de la Asociación Peruana para el Progreso de la Ciencia*, vol. i, 1921, p. 16.

[5] J. W. Salter, *Quart. Journ. Geol. Soc. Lond.*, vol. xvii, 1861, p. 62.

[6] F. Toula, *Sitz. d. k. Akad. d. Wiss., Math.-naturw. Kl.*, Wien, lix, 1, 1869, p. 433.

[7] W. M. Gabb, *Journ. Acad. Nat. Sci. Phil.*, vol. viii, 2nd ser., 1874–81, pt. iii, p. 302.

Kozlowski,[1] Meyer,[2] and Douglas[3]; the Amazonian faunas have been well described by Derby[4] and Katzer[5]; while references to more southerly occurrences are made by, among others, Phillippi[6] (in Chile), Siemiradzki[7] (in Patagonia), Stappenbeck[8] (in Argentina), and Holdhaus[9] (in South Brazil). Cowper Reed[10] quite recently has described several forms in an Argentinian fauna.

In all those areas the main element of the fauna is furnished by the Brachiopoda, though other groups occur. The fauna from North-Western Peru, however, is comparatively poor in articulate brachiopods, though *Chonetes variolatus* (d'Orb.) — often in large numbers—*Spirifer condor* d'Orb., *Sp. cameratus* Morton, etc., are found. Numerous inarticulate brachiopods occur, though the mollusca are the dominant groups.

LAMELLIBRANCHIA.

FAMILY PECTINIDAE.

Genus AVICULOPECTEN M'Coy.

The genus *Aviculopecten* was created by M'Coy[11] for the reception of certain pectinoid shells with the posterior ear longer than the anterior ear, and believed to lack a central chondrophore on the hinge plate. The evidence for the absence of the latter was based on certain casts.[12] Etheridge[13] showed the presence of a cartilage-pit and of a longitudinally striated hinge-plate in an Australian Permo-Carboniferous form, and, assuming *Aviculopecten* to be devoid of such, erected a new genus, *Deltopecten*, for its reception, later uniting other species in that genus.[14] Girty, rejecting his own genus

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[1] R. Kozlowski, *Ann. de Pal.*, t. ix, 1914.

[2] H. L. F. Meyer, *Neues Jahrb. für Min.*, Bd. xxxvii, 1914, pp. 590–652.

[3] J. A. Douglas, *Quart. Journ. Geol. Soc. Lond.*, vol. lxx, 1914, pp. 1–51; vol. lxxvi, 1920, pp. 1–59.

[4] O. A. Derby, "On the Carb. Brach. of Itaituba," *Bull. Cornell Univ., Science*, No. 2, 1874; "The Amazonian Upper Carboniferous Fauna," *Journ. Geol.*, ii, 1894, pp. 480–501.

[5] F. Katzer, *Neues Jahrb. für Min., etc.*, Bd. ii (Stuttgart), 1897, p. 218; *Grundzüge der Geologie des unteren Amazonas.*, Leipzig, 1903, pp. 142–88, 263–8, pls. iv–viii.

[6] R. A. Phillippi, *Zeit. d. deut. geol. Gesell.*, l, Berlin, 1898.

[7] I. von Siemiradzki, *Sitz. d. k. Akad. d. Wiss. Math.-naturw. Kl.*, Wien, cvii, 1898.

[8] R. Stappenbeck, "Geol. Aufbau d. Vorkordillere," *Geol. u. Pal. Abhandl.* N.F., Bd. ix, Heft 5, 1911, pp. 31, 32.

[9] K. Holdhaus, "Sobre alguns Lamellibranchios Fosseis do Sul do Brasil," *Mon. Serv. Geol. e Min. do Brasil*, vol. ii, 1919.

[10] F. R. C. Reed, "Upper Carb. Foss. from Argentina," in A. L. du Toit's *A Geol. Comp. of S. America with S. Africa*, Carnegie Inst. Washington, No. 381, 1927, pp. 129–58.

[11] M'Coy, *Ann. Mag. Nat. Hist.*, 2nd ser., vol. vii, 1851, p. 171.

[12] M'Coy, ibid., and *Brit. Pal. Foss.*, 1855, pp. 392, 485–6, pl. 3*e*, fig. 6.

[13] Jack and Etheridge, *Geol. and Pal. of Queensland*, 1892, p. 269, pl. xli, fig. 3; pl. xliii, fig. 2.

[14] Etheridge, *Monog. Carb. and Permo-Carb. Invert. of N. S. Wales*, 1906, pp. 22 et seq.

Limipecten[1] on the grounds of the priority of Etheridge's genus, has referred several North American Carboniferous species with a central chondrophore to *Deltopecten*,[2] including *A. occidentalis* (Shum.). In this species Meek and Worthen[3] had already observed the cartilage-pit. The possession of the latter and of a striated hinge-plate was shown in *A. semicostatus* Portlock sp. (=*A. docens* M'Coy) by Hind,[4] i.e. in the same species as that from casts of which M'Coy had inferred the absence of the chondrophore in the genus.

In one of the Peruvian species described below, *A. multiscalptus* sp. nov., the umbo of the left valve certainly overhangs the hinge-line as in several of the species referred to *Deltopecten* by Etheridge and Girty, and in one specimen there is the suggestion of a central chondrophore. But since the absence of a central cartilage-pit in *Aviculopecten* cannot be taken as definitely proved (the original statement, in fact, appearing quite arbitrary), and since on that depends the validity of *Deltopecten*, the former generic term is used for *A. multiscalptus* in preference to the latter.

Aviculopecten multiscalptus sp. nov.
(Pl. V, Figs. 1, 3–8*a*.)

This species is one of the commonest in the collection, and, at the same time, it is found at three of the fossiliferous horizons. Most, however, come from the "Goniatite Bed".

Diagnosis.—Valves medium to large, nearly circular, with the direction of growth perpendicular to the hinge-line, or only slightly posterior to that direction. Height and length almost equal.

Hinge-line straight, about three-quarters the greatest width of the shell, which occurs at about two-fifths of the height from the ventral margin. Hinge-plate longitudinally striated, and apparently with a central, deltoid cartilage-pit.

Left valve moderately convex, though slightly variable, with a small, incurved umbo projecting a little above the hinge-line and leaving a small triangular area above the latter. Both ears of medium size, the posterior ear slightly longer than the anterior. Anterior ear convex, fairly well defined by the umbonal slope—in some forms this is rather steeper than in others—but the flattened posterior ear is less well differentiated from the rest of the shell. The hinge-line meets the anterior margin of the former at an angle slightly greater than a right angle, while the posterior ear terminates acutely and is bounded by an even curve. Below the ears the valve is smoothly and regularly rounded.

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[1] Girty, *U.S. Nat. Mus. Proc.*, vol. xxvii, 1904, p. 721.

[2] Girty, U.S.G.S. Prof. Paper 58, 1908, p. 405; Bull. 377, 1909, pp. 30–2; Bull. 389, 1909, pp. 84–9; Bull. 439, 1911, pp. 89, 90; Bull. 544, 1915, pp. 132–4; Bull. 593, 1915, pp. 163–6.

[3] Meek and Worthen, *Geol. Surv. Ill.*, vol. ii, Palaeontology, 1866, p. 331, footnote.

[4] Hind, Geol. Mag., n.s., Dec. V, Vol. III, 1906, p. 59, and Fig.

Left valve ornamented with very numerous radiating ribs, and with numerous, faint, closely arranged, concentric striae which are often quite indistinct. The ribbing is somewhat variable, and the nature of the preservation very markedly determines the appearance of the shell. There are nine or ten primary ribs, of which the anterior five are directed anteriorly downwards, with a secondary rib, which enters near the umbo and which very rapidly assumes an importance only slightly less than that of the primary ribs, in between each pair of primaries. A narrower tertiary rib occupies the centre of the interspaces so formed, with a much finer rib on either side of it. Anteriorly the primary and secondary ribs are indistinguishable, and are smaller and finer than over the centre of the shell. On larger specimens the secondary ribs appear to become less distinct from the primaries, while two or three very fine ribs occupy the interspaces between the stronger ribs. The concentric striae are continued on to the ears where they are much more closely arranged. Each ear has nine or ten fine radiating ribs, those of the posterior ear being less strong than those of the anterior ear. Internal casts show only the stronger ribs and a few concentric growth lines.

Right valve (known from a few specimens) flat, or nearly so, terminating in a very small, acute umbo not projecting beyond the hinge-line, and directed anteriorly. Anterior ear well differentiated from the rest of the valve by the deep byssal sinus: posterior ear less sharply defined. The ornamentation consists of numerous radiating ribs with secondary ones entering at about half the height of the valve—the ribs are a little finer than those of the left valve. Concentric striae, if present originally, are not shown on most of the specimens. On both ears, however, they are well developed, being very fine and closely arranged. In addition, on the anterior ear are about eight fine, rounded, radiating ribs, and on the posterior ear are about ten very fine ones with flat intercostal spaces.

Both valves show a few concentric furrows.

Dimensions (of holotype).—Height = c. 22·5 mm.; length = c. 22·0 mm.; thickness = 6·5 mm.; umbonal angle = 75°.

Remarks.—Only a few species of *Aviculopecten* have been described from South America. From Bolivia d'Orbigny[1] described *A. paradezii*, a form quite different from the new Peruvian species. Derby[2] mentions six species from Brazil, viz., *A.* (*Deltopecten*) *occidentalis* (Shum.), *A.* (*Acanthopecten*) *carboniferus* (Stevens), *A.* (*Euchondria*) *neglectus* (Gein.), *A. coxanus* M. and W., and an *Aviculopecten* sp. somewhat like *A. providencesis* (Cox), as well as *A.* (*Streblopteria*) *hertzeri* Meek—unfortunately not one of the long list of fossils he records is figured. Of these species *A. occidentalis*, *A. carboniferus*, and *Euchondria neglectus* are recorded by Katzer.[3]

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[1] D'Orbigny, op. sup. cit., p. 44, pl. iii, fig. 11.

[2] Derby, *Journ. Geol.*, vol. ii, 1894, pp. 494, 495.

[3] Katzer, *Grundzüge der Geologie des unteren Amazonas.*, 1903, pp. 166, 176, 180, 184, pl. viii, figs. 3–6.

In addition Cowper Reed[1] has described *A. barrealensis* from Argentina. Of all these forms only *A. occidentalis* is closely allied to *A. multiscalptus*, but the latter is distinguished by the greater differentiation between the primary, secondary, and tertiary ribs of the left valve.

Another North American Pennsylvanian form, *A. coreyanus* White,[2] is also of the same type but differs in its larger size, in its ornamentation, and in the character and ornamentation of the ears.

A. hiemalis Salter[3] is very closely allied to the Peruvian species, and differs chiefly in its proportions, the length being greater than the height, while the umbonal angle is greater, too.

Localities.—" Goniatite Bed," Pariñas Quebrada; junction of the Sullana Road, Pariñas Quebrada; Gramadal Quebrada (3 miles above junction with Pariñas Quebrada).

Aviculopecten bravoi sp. nov.

(Pl. V, Figs. 2, 10, 10*a*.)

Unfortunately there is only one example of this species in the collection, a left valve, but its characters are such as to justify the creation of a new specific name for its reception. The impression of a right valve from the same locality may belong to this species.

Diagnosis.—Valve of medium size, moderately convex, posteriorly elongate, the height slightly less than the length. Hinge-line straight, two-thirds the greatest length, which occurs at about two-fifths the height from the inferior margin. Direction of growth obliquely posterior. Umbo small, scarcely projecting beyond the hinge-line. Ears flattened, the anterior one slightly shorter than the posterior ear and more distinctly differentiated from the rest of the valve by the steep, anterior umbonal slope. From its blunt junction with the hinge-line, the anterior margin of the anterior ear curves slowly forwards and then backwards to form the shallow indentation where it unites with the rest of the valve. Posterior ear longest at the hinge-line, with which its posterior margin makes a wide acute angle, while the indentation beneath it is wider and deeper than that beneath the anterior ear.

The ornamentation of the valve consists of radial ribs and numerous fine, concentric striae which are slightly convex to the umbo between the ribs. There are about eleven primary ribs, of which the anterior four are directed anteriorly downwards. Secondary ribs come in very close to the umbo, and very rapidly become almost as strong as the primaries. The tertiary ribs are much finer, and the spaces between these and the larger ribs are occupied by two or three somewhat finer ribs. Both the anterior and posterior ears are radially striated, but the ribs on the posterior ear are much less prominent than those of the anterior ear, which are about fourteen to sixteen in number. The concentric striae are also finer and more compressed, especially in the case of the posterior ear, than they are on the rest of the valve.

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[1] Cowper Reed, op. sup. cit., p. 142, pl. xiii, fig. 14.

[2] White, *Prelim. Rept. Inv. Foss.*, 1874, p. 21.

[3] Salter, *Pal. Niti in the N. Hims., etc.*, Salter and Blanford, 1865, Calcutta, p. 55, pl. v, fig. 14; " Himalayan Fossils," C. Diener, vol. i, pt. iv (*Pal. Ind.*, ser. xv), 1915, pp. 9–13, pl. v, figs. 10*a*, 10*b*, 11.

The external mould of a part of a right valve may belong to this species. It is flat, posteriorly oblique, apparently with a very small umbo. The ornamentation consists of numerous radiating ribs, with new ribs intercalated at about half the height of the valve. Several concentric furrows are present. Anterior ear well defined by the deep byssal sinus, and ornamented with numerous fine, concentric striae, and with a few radiating ribs.

Dimensions (of holotype).—Height = 24 mm.; length = c. 27 mm.; thickness = 6·5 mm.; umbonal angle = 85°.

Remarks.—There is no difficulty in differentiating between this and the foregoing species. Similar to the Peruvian form is *A. clathratus* (M'Coy),[1] especially those figured by Hind,[2] but in the latter the ears are somewhat smaller and the anterior ear less depressed, the valve is more elongate and less inflated, the umbonal angle is greater, and the ribs are not so strong. *A. interstitialis* (Phill.) [3–4] is also similar, but *A. bravoi* is wider, has more numerous ribs, and the posterior ear is of a very different shape.

There is a certain similarity between *A. katwahiensis* Waagen [5] and the Amotape species, but the latter has, among other differences, bolder ribbing.

Locality.—Steel Hill, Pariñas Quebrada.

Aviculopecten sullanaensis sp. nov.

(Pl. V, Fig. 9.)

This species is founded on a single specimen, a left valve.

Diagnosis.—Valve of moderate size, almost equilateral; height and length apparently equal. Inflation moderate, at a maximum at about one-third the height from the umbo. Umbo small, low, tumid. Anterior ear well defined from the rest of the valve by the anterior umbonal slope, but the post-umbonal slope is less steep, resulting in the posterior ear being less well defined. The ornamentation of the valve consists of about ten narrow, primary radial ribs, with smaller secondary ones in between, the interspaces being occupied by three finer ribs of which the central one comes in the earliest and is slightly the strongest. Only near the ventral margin is there evidence of fine concentric striae having been present. The anterior ear shows nine or ten fine radiating ribs (of about the strength of the tertiary ribs of the rest of the valve) crossed by numerous fine, concentric striae. The ornamentation of the posterior ear is indeterminate.

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[1] M'Coy, *Synops. Carb. Foss. Ireland*, 1844, p. 90, pl. xiv, fig. 12.

[2] Hind, "Brit. Carb. Lamell.," vol. ii, 1903, *Mon. Pal. Soc.*, p. 82, pl. xv, figs. 1–7.

[3] Phillips, *Geol. Yorks.*, 1836, pt. ii, p. 212, pl. vi, fig. 24.

[4] Hind, op. cit., pp. 94–7, pl. xiv, figs. 16–21.

[5] Waagen, "Salt Range Fossils," vol. i (*Pal. Ind.*), 1887, p. 313, pl. xxv, fig. 1.

Dimensions (of holotype).—Height = c. 12·5 mm.; length = c. 12·5 mm.; thickness = 8·5 mm.; umbonal angle = 88°.

Remarks.—This species is distinguished from *A. bravoi* by the greater inflation and the equilateral shape of the former. The ornamentation is, however, very similar.

A. interstitialis (Phill.)[1] and *A. ruthveni* (M'Coy)[2] as figured by Hind[3] both resemble *A. sullanaensis*, but are more oblique and have fewer ribs. *A. mccoyi* Meek and Hayden[4] shows an analogous ornamentation but the strong costae of their species are knotted.

Locality.—Sullana Road, 1½ miles south of El Muerto.

EXPLANATION OF PLATE V.

All figures are of the natural size, except where otherwise stated.

FIG.

1.—*Aviculopecten multiscalptus* sp. nov., holotype. Left valve. Goniatite Bed, Pariñas Quebrada.

2.—*Aviculopecten bravoi* (?) sp. nov. External mould of a right valve. Steel Hill, Pariñas Quebrada.

3.—*Aviculopecten multiscalptus* sp. nov. A left valve. Goniatite Bed, Pariñas Quebrada.

4.—Do. A left valve, somewhat worn. Same locality.

4*a*.—Do. External mould of right valve of Fig. 4.

4*b*.—Do. Right valve of Fig. 4, showing overhanging umbo of the left valve.

4*c*.—Do. External mould of the posterior ear of the right valve of Fig. 4, × 2·5.

4*d*.—Do. External mould of the anterior ear of the right valve of Fig. 4, × 2·5.

5.—Do. A left valve, showing the anterior ear. Junction of the Sullana Road, Pariñas Quebrada.

6.—Do. External mould of a right valve, with the impression of the hinge-plate of the left valve. Gramadal Quebrada, 3 miles above the junction with the Pariñas Quebrada.

7.—Do. A left valve, showing the ornamentation of the posterior ear. Goniatite Bed, Pariñas Quebrada.

8, 8*a*.—Do. Left and right valves of a somewhat distorted specimen. Same locality.

9.—*Aviculopecten sullanaensis* sp. nov., holotype. Left valve. Sullana Road, 1½ miles south of El Muerto.

10.—*Aviculopecten bravoi* sp. nov., holotype. Left valve. Steel Hill, Pariñas Quebrada.

10*a*.—Do. Ornamentation of part of the same specimen, × 2·5.

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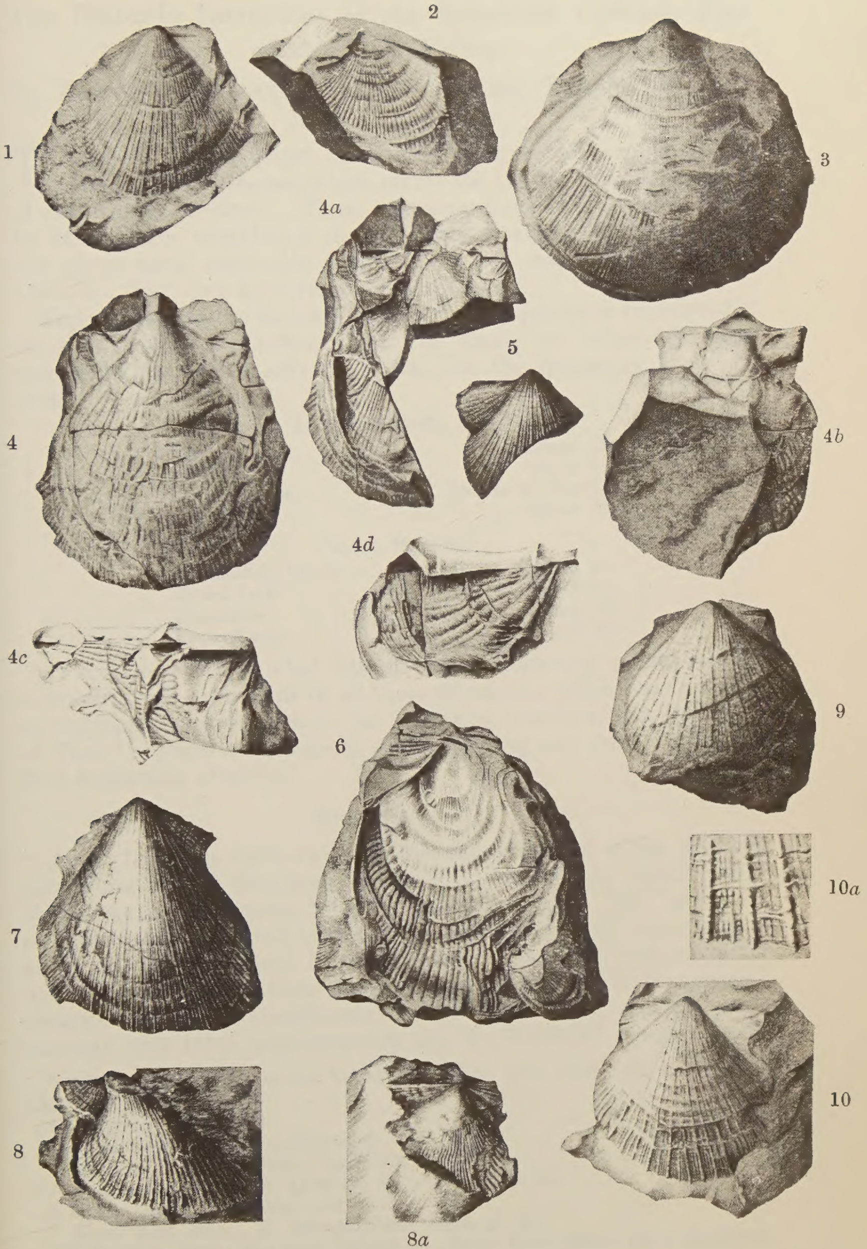
[1] Hind, op. cit., vol. ii, pp. 94–7, pl. xiv, figs. 16–21.

[2] M'Coy, *Brit. Pal. Foss.*, 1855, p. 489, pl. 3*e*, fig. 4.

[3] Hind, op. cit., vol. ii, p. 97, pl. xiv, fig. 22.

[4] Meek and Hayden, *Pal. Upper Mo.*, 1864, p. 50, pl. ii, fig. 9.

(To be continued.)



C.B.B. and E.T.T. del.

PERUVIAN CARBONIFEROUS LAMELLIBRANCHIA.

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The Plutonic Intrusions of the Southern Uplands East of the Nith Valley.

By FREDERICK WALKER, Carnegie Teaching Fellow, University of St. Andrews.

THE object of this paper is to give a connected account of the small plutonic masses which pierce the Lower Palaeozoic strata of South-East Scotland. These intrusions have been overshadowed by their larger neighbours the Galloway Granites, of which Teall has given such admirable descriptions, but are worthy of more attention than they have received in the past.

Eight masses fall to be considered, and their positions are indicated on the sketch-map below. Four of them are relatively large intrusions, at least a mile in length, but the remainder are quite small :—

LARGE MASSES.	
Spango	Sheet 15
Polshill	Sheet 15
Cockburnlaw . . .	Sheets 33 and 34
Priestlaw . . .	Sheet 33
SMALL MASSES.	
Lamberton Beach . .	Sheet 34
Broad Law . . .	Sheet 25
Kernielaw . . .	Sheet 25
Lyne Water . . .	Sheet 32

It will be shown in what follows that a magma of quartz-dioritic composition is prominent in all these intrusions, which bear a strong petrographic resemblance to the Galloway tonalites and hyperites of Teall[1]; while six chemical analyses bring out their Lower Old Red Sandstone affinities.

BIBLIOGRAPHY.

Apart from the Galloway Granites the literature of the plutonic intrusions of the Southern Uplands is exceedingly scanty, contributions in recent years being particularly scarce. The "granite" of Priestlaw has figured in the writings of many early investigators such as Playfair,[2] Ami Boué,[3] Jameson,[4] but the first complete account of its field relations was given by A. Geikie.[5] W. Stevenson[6] describes fully the Cockburnlaw mass in the field, and his early account was later supplemented by A. Geikie's[7] work. Teall[8] gives brief petrological notes on these masses in the relevant Survey memoirs. Still briefer notes of the Spango and Polshill masses appear from his pen in the Southern Uplands memoir,[1] but Mr. John Smith [2] has given a detailed account of the field characters of the Spango "granite". The small plutonic intrusion in the Lyne Water above Baddingsgill has been stated in the Edinburgh memoir [3] to be "too much decomposed for accurate determination", while a few lines in the early East Berwickshire memoir by A. Geikie [4] describe the field relations of the tiny boss at Lamberton Beach.

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[1] "Silurian Rocks of Great Britain": *Mem. Geol. Surv.*, pt. i, Scotland, 1899, pp. 607–25.

[2] *Illustrations*, p. 328.

[3] *Essai Geologique sur l'Ecosse*, p. 94.

[4] *Mineralogy of Dumfries*, Appendix.

[5] *Mem. Geol. Surv.*, E. Lothian, 1st ed., pp. 15–17.

[6] *Trans. Roy. Soc. Edin.*, vol. xvi, p. 39.

[7] *Mem. Geol. Surv.*, E. Berwickshire, 1864, p. 29.

[8] "Silurian Rocks of Great Britain": *Mem. Geol. Surv.*, pt. i, Scotland, 1899, p. 625; E Lothian, 2nd ed., 1911, p. 22.

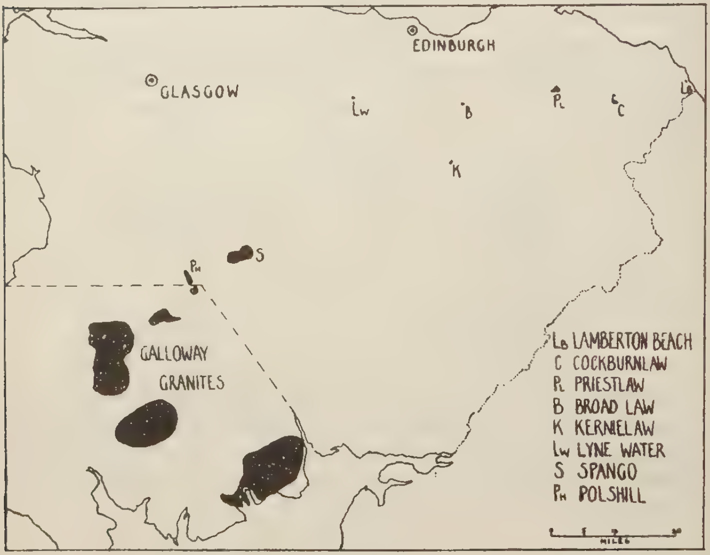

Fig. 1.—Map showing distribution of plutonic intrusions of the Southern Uplands.

No mention has been found of the intrusions on Broad Law and Kernielaw.

A few years ago the author [5] gave a short petrological account of the masses of Cockburnlaw, Priestlaw, Broad Law, and Lamberton Beach. This work has been revised and extended in the present article to include the four remaining masses, while four new chemical analyses have been made.

[1] Op. cit., p. 625.

[2] *Trans. Glasgow Geol. Soc.*, vol. x, p. 256.

[3] Op. cit., p. 27.

[4] Op. cit., p. 40.

[5] *Trans. Edin. Geol. Soc.*, vol. xi, pt. iii, pp. 357–65.

FIELD CHARACTERS.

The eight masses all occur on the smooth green slopes or desolate moors of the Southern Uplands: only in the intrusions of Cockburnlaw and Polshill is any approach to Lowland scenery seen, some part of both these bosses lying amongst cultivated ground and trees. Exposures are never strikingly good, and the remote situation of the masses has prevented them from being quarried for road metal except in the case of Broad Law. All the intrusions appear to have the form of bosses, though no contacts are visible.

Spango.—The large igneous mass commonly known as the Spango granite is situated on the Spango Water in the midst of bleak hills which lie on the border of Lanarkshire and Dumfriesshire. It measures 3¼ miles by 1¾ and is somewhat inaccessible, the nearest outcrops being 2 miles from the secondary road which connects Crawfordjohn and Sanquhar. The mass is traversed by the Spango Water and several tributary streams, but exposures are poor, particularly to the north. The best occur at intervals along the left bank of the Spango Water, and along the Brocklaw, Fingland, and Gareland Burns. Good specimens may also be obtained from the lower slopes of Shiel Hill. No contacts with sediments are to be seen, but the mass appears to be intrusive into arenaceous strata of Glenkiln (Llandeilian) age, which have been intensely altered. The intrusion has been truncated to the north by the great fault which forms the southern boundary of the Midland Valley, and lets down Lower Old Red Sandstone strata against Ordovician.

Polshill.—The Polshill granite occurs on the right bank of the River Nith 5 miles west of Kirkconnel and stretches up the hillside for about 1¼ miles towards its companion mass of "The Knipe", which consists of an almost identical rock. It is never more than ⅓ mile in breadth. Good exposures occur along the Polshill burn above and below the bridge and on the rocky knobs which rise S.E. of the deserted sheiling ½ mile south of the Cumnock-Kirkconnel road. The mass is intrusive into strata of Arenig age and has greatly altered both lavas and radiolarian cherts, though no contact was detected. It is very probably truncated to the south by an important fault letting down Devonian and Carboniferous strata against Lower Palaeozoic.

Priestlaw.—The granite of Priestlaw, in area about 1 square mile, lies in the heart of the Lammermuir Hills at the junction of the rivers Whiteadder and Faseny, and is crossed by the Gifford—Duns road. Good exposures are confined to the banks of the Faseny, where the striking contact alteration of the Lower Silurian greywackés may be studied to advantage, though the actual junction narrowly misses exposure. Several dykes of decomposed porphyrite cut the mass.

Cockburnlaw.—The igneous mass which forms the eminence of Cockburnlaw and Stoneshiel Hill lies 3 miles to the north of

Duns, and is well dissected by the river Whiteadder, which has cut a deep ravine through it. Exposures are abundant on either side of the ravine up to the summits of both hills. The intrusion covers an area of approximately 1 square mile, and has been injected into greywackés of Lower Silurian age which have been extensively hornfelsed. Pebbles of the igneous rock and its metamorphic aureole may be seen in the adjacent Upper Old Red conglomerates, while the granite is traversed by an E.–W. dyke of quartz-dolerite, probably of Permo-Carboniferous age.

Broad Law.—The small intrusion of Broad Law is situated on the face of the Moorfoot Hills, 3 miles west of Heriot. It is elliptical in shape, the major diameter being slightly over half a mile and running parallel to the strike of the surrounding Llandeilian strata. The igneous rock is well exposed in a series of abandoned road-metal quarries, but is deeply weathered, the freshest material coming from the waste dumps; elsewhere the intrusion and its aureole are thickly covered by peat.

Kernielaw.—A very small boss of igneous rock occurs on the ridge of Kernielaw above Innerleithen and was exposed during the construction of a reservoir at that point. No contacts with the surrounding Lower Silurian strata are seen.

Lamberton Beach.—At Lamberton Beach, some 4 miles N.W. of Berwick, a tiny boss of acid rock is exposed on a mound just below the L.N.E.R., and is seen to be capped by Upper Old Red conglomerate which contains pebbles of the underlying igneous rock. The boss is truncated to the north by a fault which lets down Carboniferous Limestone strata against it; and it is cut by a decomposed lamprophyre dyke.

Lyne Water.—At the junction of the Ravendean Burn with the headwaters of the Lyne, about 4½ miles N.N.W. of West Linton, occurs another small boss of dioritic-looking rock which is intrusive into the surrounding Lower Old Red Sandstone. Spheroidal weathering may be observed at the few scanty exposures.

PETROLOGY.

The rock-types in the masses under consideration show but little variety, all being either medium-grained granodiorites or quartz-diorites,[1] though the porphyritic nature of some of the marginal modifications justifies their inclusion amongst the porphyrites. The most abundant type is undoubtedly a basic hornblende-biotite-granodiorite, but varieties with monoclinic and rhombic pyroxene may also occur. A brief account of the chief mineral constituents follows before treatment of the individual masses:—

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[1] The above names are used in accordance with the recommendations of the Committee on British Petrographic Nomenclature, vide *Mineralogical Magazine*, vol. xix, No. 92, p. 137.

Quartz.—This mineral occurs in all the types, varying in quantity from 22 per cent in the most acid to 6 per cent in the most basic. It possesses all the usual optical characters, contains fluid inclusions, and is nearly always of late crystallization, being occasionally preceded even by orthoclase.

Orthoclase.—The only alkali felspar detected was orthoclase, which varies from 21 per cent to 5 per cent according to the acidity of the rock. It usually occurs in large plates, often rendered rather turbid by alteration, which wrap round the other constituents, but may in the porphyrites assume a granular habit. Both perthitic intergrowth with oligoclase and graphic intergrowth with quartz are very rare.

Plagioclase.—The plagioclase is usually quite well formed and shows marked zonal banding. It may range from oligoclase to acid labradorite, but the most common variety is andesine. Always by far the most abundant constituent present, it may form up to 60 per cent of the rocks. Besides the common twinning on the Carlsbad and albite laws, pericline twinning may occasionally be detected. In the porphyrites zoning is often accentuated by magnetite dust.

Biotite.—Chestnut brown biotite with intense absorption is always present, sometimes amounting to 20 per cent, and generally being the most abundant ferromagnesian mineral. It often occurs as well-formed hexagonal flakes, but may fringe crystals of pyroxene. The chief decomposition products are chlorite and carbonates, but epidote has also been observed. Pleochroic haloes round small zircon crystals are not uncommon.

Hornblende.—Common hornblende is only absent from some of the hypersthene-porphyrites and is sometimes as abundant as biotite. In the granodiorites it is of the green variety, but in the quartz-diorites it assumes a brownish tinge, while the amphibole of the Lyne Water rock is deep red-brown in colour. The maximum extinction angle ($Z \wedge c$) is always in the neighbourhood of 20°. The crystals show great variety in size, but are usually well-formed, often showing the terminal faces clearly while they exhibit simple or lamellar twinning. Alteration to chlorite is prevalent.

Augite.—Monoclinic pyroxene is present in some of the quartz-diorites, but never exceeds 10 per cent in quantity. Except in the porphyrites, where it may occur as large well-formed crystals, it forms shapeless grains, though of early crystallization, sometimes being surrounded by hornblende. In its optical properties it agrees well with the malacolite of Teall. It may show simple or lamellar twinning, and has a tendency to form polysynthetic aggregates. The chief decomposition products are chlorite and carbonates.

Hypersthene.—Rhombic pyroxene is confined to the porphyrites, where its medium-sized crystals may make up as much as 15 per cent of the rock. It usually exhibits distinct pink-green pleochroism and is always well-formed. Alteration to bastite is common.

Accessory Minerals.—The most ubiquitous accessories are magnetite and apatite, but clove-brown sphene is often seen in the more acid varieties. Zircon and epidote are less common, while orthite is confined to the Spango mass, and tourmaline to the margin of the Polshill intrusion.

POLSHILL AND COCKBURNLAW.

The two masses of Polshill and Cockburnlaw have many points in common. In both, the centre of the masses consists of a basic hornblende-biotite-granodiorite or quartz-diorite in which andesine is approximately three times more abundant than orthoclase. In the Cockburnlaw intrusion this rock is pink as a rule, while a grey colour prevails over most of the Polshill mass. These hornblendic rocks give place gradually outwards to pyroxene-bearing modifications, first augite and then hypersthene appearing, while porphyritic texture becomes well marked at the margin. The groundmass of these marginal porphyrites contains many small idiomorphic crystals of alkali felspar included in quartz, giving the rock a curious speckled appearance under crossed nicols. Such porphyrites are well seen along the eastern border of the Cockburnlaw mass and the southern margin of the Polshill mass. In the Polshill porphyrite numerous half-digested xenoliths occur, and in one section a large crystal of blue and brown tourmaline was detected. The rocks with monoclinic pyroxene represent the intermediate stages between hornblende-biotite-granodiorite and quartz-hypersthene-porphyrite, and are best represented at the summit of Cockburnlaw and on the western slopes of Stoneshiel Hill. At the summit of Stoneshiel Hill the granodiorite contains a curious and scanty micrographic groundmass.

PRIESTLAW.

The centre of the Priestlaw mass consists of a fairly acid pink hornblende-biotite-granodiorite with a scanty micrographic groundmass, as on Stoneshiel Hill. This changes by degrees to a more basic non-porphyritic granodiorite as the margin is approached, which in its turn gives place gradually to a slightly porphyritic grey quartz-augite-biotite-diorite. In this marginal rock hornblende is often almost completely absent, such scraps as do occur having a distinct brown tinge. Sphene is a conspicuous accessory in this mass; and aplite veins of quartz and orthoclase appear marginally.

SPANGO.

The rock of the large Spango mass shows very little variation and is a basic hornblende-biotite-granodiorite or quartz-diorite in which andesine is usually three times more abundant than orthoclase. Graphic and perthitic intergrowths are of infrequent occurrence in the rock, which, when fresh, is grey in colour, but is frequently stained red by percolating waters. The only important variation from this type is seen on the western slopes of Shiel Hill, where small crystals of colourless augite make their appearance. This mineral is, however, only an accessory and does not make up more than 3 per cent of the rock. The above type is the only approach to a distinct marginal modification detected in the intrusion. Aplitic veins similar to those in the Priestlaw mass occur, and sedimentary inclusions may be observed rarely. Sphene is an ubiquitous accessory, while well-formed zonal crystals of orthite have been observed on the lower slopes of Shiel Hill.[1]

KERNIELAW, BROAD LAW, AND LAMBERTON BEACH.

The rock which makes up the small intrusions of Broad Law and Kernielaw is almost identical with that forming the summit of Stoneshiel Hill, a micrographitic groundmass being conspicuous in all these localities. The Lamberton Beach occurrence, however, is of even grain, though otherwise very similar to the above type. The rock of all three intrusions is grey in colour and somewhat decomposed, hornblende being invariably altered to chlorite.

LYNE WATER.

Although the rock of the small Lyne Water plutonic is far from fresh, it is scarcely beyond determination. The type is unlike that of any of the other intrusions, being distinctly basic. Decomposed plagioclase felspar (probably andesine) is the most abundant constituent, while orthoclase is rare if present at all. The ferromagnesian minerals include colourless augite, dark reddish-brown hornblende ($Z \wedge c = 15°$) and biotite of an almost exactly similar reddish-brown tint. The last three minerals occur in rather irregularly shaped masses. Quartz, some of which is undoubtedly secondary, occurs interstitially, and is occasionally crowded with long slender needles of light green amphibole with an extinction angle of 15°.

The most interesting of the above types are undoubtedly the granodiorites with micrographitic groundmass which occur in the centre of the Priestlaw mass and on Stoneshiel Hill. They do not find their origin in rapid cooling, for both pass outwards into even-grained types, and in this way they differ from the porphyritic marginal modifications. In a former paper the author [2] attributed the two generations of quartz and orthoclase to the last of the Caledonian series of earth-movements which, by increase of pressure, were thought to upset the equilibrium of crystallization and produce many new crystal nuclei, while some of the quartz and orthoclase of the central rock was still liquid. A fine-grained groundmass would thus be formed. The presence of aplite veins in the rapidly cooled marginal rock, and the slight flexures in the Carlsbad twin-planes of the central rock were taken as evidence of such movements during consolidation. This explanation may indeed meet the case, but Bowen[1] has shown experimentally how porphyritic texture may be produced by quite continuous crystallization and the aid of earth-movements need not, therefore, be invoked at all. The author has encountered similar phenomenon in certain of the newer granites of Aberdeenshire. Lack of space precludes description of the metamorphic aureoles of the above masses, which are important enough to warrant separate treatment.

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[1] Cf. Sir John Flett, GEOL. MAG., 1898, p. 388.

[2] Op. cit., p. 363.

Age and Affinities.

With the exception of the small Lyne Water mass all the intrusions closely resemble one another, and may be regarded as consanguineous. They have all escaped foliation by the main Caledonian Movements and are therefore post-Silurian, while pebbles of them found in conglomerates of Upper Old Red Sandstone age establish an upper age limit. Though they may conceivably be of Middle Old Red Sandstone age there is a strong probability that they belong to the Lower division of the system like many of their neighbours, to which they show marked similarities in chemical and mineralogical composition. There is, in fact, every reason to believe that they are the underground expression of the volcanic activity which was so prevalent in Scotland during Lower Devonian times. Though it cuts beds of Lower Old Red Sandstone age and is distinctly more basic, the Lyne Water intrusion also is probably to be correlated with this activity, being quite unlike any known Carboniferous rock.

Six chemical analyses bring out clearly the resemblance of these plutonic masses to lavas, hypabyssal, and plutonic intrusions of similar age from neighbouring districts, the correspondence of these analyses with others from Forfarshire, Argyllshire, and Galloway being very marked. The prominence of a granodioritic or tonalitic magma over a large area is, indeed, one of the striking features of Lower Devonian igneous activity. It will be noticed that the analyses show exceedingly close agreement amongst themselves, and that the marginal pyroxene-bearing rock of Cockburnlaw differs little in composition from the central granodiorite. The appearance of pyroxenes in place of hornblende at the margin of the Cockburnlaw mass is, therefore, due rather to loss of volatile constituents and rapid cooling than to any decrease in the silica percentage. The same may be said in a lesser degree of the Spango mass; but the Priestlaw granodiorite has a very marked basic margin.

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[1] *Amer. Journal Sci.*, **1914, p. 257.**

ANALYSES.

	I.	A.	II.	B.	III.	IV.	C.	V.	VI.	D.
SiO_2	65·03	65·19	57·15	56·80	60·80	59·55	60·05	58·60	57·40	58·31
TiO_2	·50	·59	·75	1·2	·45	1·00	·42	·63	1·10	·87
Al_2O_3	16·69	16·31	18·39	18·51	17·76	17·80	18·55	18.05	19·64	16·97
Fe_2O_3	1·19	·61	1·42	2·56	·73	1·12	·93	1·47	·46	1·45
FeO	2·04	3·44	4·25	2·97	4·30	4·14	3·41	4·14	4·96	4·42
MgO	2·25	1·50	3·54	3·55	3·02	2·86	3·46	3·49	2·41	4·09
CaO	3·61	3·41	5·75	5·70	4·30	4·10	5·44	5·30	5·70	5·66
Na_2O	3·65	4·72	3·81	3·76	4·50	3·71	3·84	3·37	3·60	3·80
K_2O	3·40	2·95	2·99	2·21	2·51	3·22	2·72	3·18	2·65	2·51
H_2O +	1·58	1·16	·20	·75	1·35	1·90	·35	·95	1·10	·79
H_2O −		·15	·80	1·85	·52	·45	·05	·65	·55	·70
P_2O_5	·19	·22	·22	·23	·16	·19	·29	·23	·26	·51
MnO	—	·17	·15	tr.	·04	tr.	·16	tr.	tr.	·05
CO_2	—	·03	·55	tr.	nil	nil	nil	nil	nil	n.d.
S	—	—	tr.	—	tr.	nil	tr.	nil	nil	—
Total	100·12	100·45	99·97	100·09	100·18	100·04 Zn0·27	99·94	100·06	99·83	100·14 Cl ·01

NORMS.

	I.	II.	III.	IV.	V.	VI.
Quartz . .	19·26	5·58	8·52	10·80	8·70	8·40
Orthoclase .	20·02	17·24	15·01	18·90	18·90	15·57
Albite . .	30·92	31·96	38·25	31·44	28·30	30·39
Anorthite .	16·96	24·46	20·57	19·46	24·46	26·41
Corundum .	·82	—	—	1·12	·10	1·12
Hypersthene .	7·58	14·58	13·80	12·08	14·11	12·73
Ilmenite .	·91	1·37	·76	1·98	1·22	2·13
Magnetite .	1·62	2·09	·93	1·62	2·00	·70
Apatite .	·34	·34	·34	·34	·67	·67
Calcite . .	—	1·20	—	—	—	—
H_2O, etc. .	1·58	1·00	1·91	2·35	1·60	1·65
	100·01	99·82	100·09	100·09	100·15	99·77

I. Porphyritic hornblende-biotite-granodiorite, centre of Priestlaw mass. Analyst, F. Walker.

A. Plutonic intrusion near Talnotry Cottage, Newton Stewart, Kirkcudbright. Analyst, E. G. Radley. Quoted from *Geol. Survey Summary of Progress for* 1923, p. 134.

II. Augite-biotite-quartz-diorite, margin of Priestlaw mass in Faseny Water. Analyst, W. H. Herdsman.

B. Hypersthene-augite-andesite, Stannergate, Dundee. Analyst, W. H. Herdsman. Quoted from J. W. Harris, *Trans. Edin. Geol. Soc.*, vol. xii, part i.

III. Hornblende-biotite-granodiorite, Spango Water, near east margin of mass. Analyst, W. H. Herdsman.

IV. Hornblende-biotite-granodiorite with accessory pyroxene, Shiel Hill, south margin of Spango mass. Analyst, W. H. Herdsman.

C. Hornblende-biotite-granodiorite, Kentallen Quarries, Ballachulish, Argyllshire. Analyst, W. H. Herdsman. Quoted from F. Walker in GEOL. MAG., 1924, p. 554.

V. Basic hornblende-biotite-granodiorite, River Whiteadder, centre of Cockburnlaw mass. Analyst, W. H. Herdsman.

VI. Quartz-biotite-hypersthene-porphyrite, River Whiteadder, east margin of Cockburnlaw mass. Analyst, W. H. Herdsman.

D. Quartz-augite-hypersthene-porphyrite, Dundee Law. Analyst, F. Walker.

ACKNOWLEDGMENT.

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The Carboniferous Outlier at Pen-Cerig-calch.

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I. INTRODUCTION.

THE hill of Pen-Cerig-calch, reaching to a height of 2,300 feet, on the southern borders of the Black Mountains, lies about 2 miles north of Crickhowell, and about 4 miles from the nearest part of the main Carboniferous outcrop above Llangattwg. It first attracted the attention of Murchison.[1] Since his time, apart from incidental references, it has not been examined in detail, and as it lies just outside the borders of the Geological Survey Sheet 232, it is not included in the description of the succession of that area given by the Survey officers.[2] The recent revision of this memoir, which includes a discussion of the zonal sequence of the Carboniferous along the main outcrop, is completed, structurally, by the following description of the sequence at Pen-Cerig-calch.

The succession is particularly interesting in that the outlier constitutes the most northerly occurrence of Carboniferous Limestone and Millstone Grit in South Wales, and the development of the former is the thinnest known in that district.

The beds dip at a low angle, about 5° or 6°, to the south-east, and as Murchison showed, this dip would bring them some thousands of feet below the beds of the main outcrop. He therefore presumed a fault to exist in the valley of the Usk to account for this discrepancy.

The writer desires to thank Mr. J. Allen Howe and Dr. T. Robertson for their kindness in permitting him to see the proofs of the new edition of the Abergavenny memoir before publication, and the latter-named gentleman for discussion on the subject of the paper. Dr. A. E. Trueman has also kindly read the paper in manuscript and made several suggestions.

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[1] R. I. Murchison, *Silurian System*, 1839, p. 162.

[2] "The Geology of the South Wales Coalfield. Part II. Abergavenny": *Mem. Geol. Surv.*, 2nd ed., 1927, p. 19.

II. DESCRIPTION OF THE SEQUENCE.

Old Red Sandstone.

The uppermost beds of the Old Red Sandstone consist of a series of sandstones, grits, and quartz-conglomerates, with very subsidiary shales and marly beds. In the Survey Memoir these are referred to as the Quartz-conglomerate Group, and are correlated with the beds which cap the Sugar Loaf to the east. They are generally of the typical red colour, but in some cases the grits and conglomerates are almost colourless, and are remarkably similar to some of the beds of the Millstone Grit. No doubt for this reason, the outcrop of massive sandstone forming Table Mountain (about

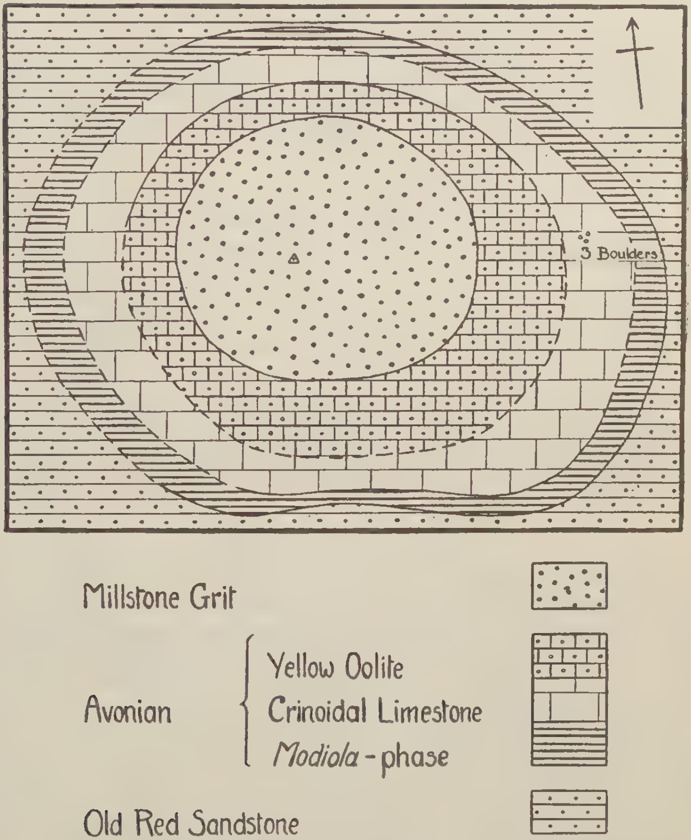

FIG. 1.—Geological Sketch-map of the Summit of Pen-Cerig-calch. Scale 4 inches = 1 mile.

half a mile to the south-east of the summit of Pen-Cerig-calch) was taken by Murchison to be of Millstone Grit age. Not being able to find any signs of a Limestone outcrop below these beds on Table Mountain, he indicated on his map (without definitely stating the fact in the text) that the Millstone Grit completely oversteps the Limestone and comes to rest directly on the Old Red Sandstone at Table Mountain. At Daren, however, half a mile to the west, an outcrop of exactly similar sandstone contains red shales and marly beds, in which Murchison himself found *Holoptychius*,[1] which indicates an Upper Old Red Sandstone age for the beds, and as these manifestly continue along the strike to the sandstone on Table Mountain, the latter also belongs to the Upper Old Red Sandstone, and may be referred to the Quartz-conglomerate Group of the Geological Survey.[2] There is therefore no marked transgression of the Millstone Grit such as Murchison indicated.

Carboniferous Limestone.

This series can be divided into three lithological groups, as follows :

		Thickness of feet.
iii.	Yellow Oolite	35–40
ii.	Crinoidal Limestone	15–20
i.	*Modiola*-phase	10–15

The *Modiola*-phase forms a notch in the profile which can be traced around the hill with ease, considerably facilitating mapping. The junction between the Yellow Oolite and the Crinoidal Limestone does not present such a pronounced surface feature, however.

(i) *The* Modiola-*Phase.*

This horizon appears to succeed the Old Red Sandstone with perfect conformity, and can be correlated with the *Modiola*-phase, which occurs at the base of the Avonian in so many and widely-separated localities of the South-West Province. The beds are typical of the horizon, and consist for the most part of thinly-bedded platy impure limestones with shaly partings and bands. Grey and yellow mudstones, including calcite-mudstones, with irregularly-bedded earthy limestones, are not uncommon. Some of the beds are reddish, but no limestones of α-type have been seen. Occasional layers are conglomeratic, and include large flat pellets of mudstone in a harder more coarsely-crystalline matrix ; these pellets are sometimes several inches across. Rounded grains of quartz, up to about 5 mm. in diameter, are not uncommon.

The fauna, as is usual, is meagre, as regards both species and individuals. The following forms are included :—

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[1] *Silurian System*, op. cit., pp. 172, 588, 601.

[2] *Abergavenny*, op. cit., p. 18.

Orbiculoidea nitida Phillips.
Modiola spp.
Ostracods.
Spirorbis sp.
Psephodus sp.

Ostracods at times crowd the beds, and form the greater proportion of the rock-forming constituents. Not infrequently, packing of the ostracod valves within one another may be observed.

(ii) *The Crinoidal Limestone.*

This is a grey, coarse-grained limestone of the "petit-granit" type, with abundant fossils. There is no abrupt change from the *Modiola*-phase, there being a gradual transition in the uppermost few feet of the latter.

Fauna :—
Avonia bassus (Vaughan).
Productus sp. nov. (= *Productus* cf. *martini* Sowerby Vaughan).
Chonetes sp.
Schellwienella cf. *crenistria* (Phillips).
Spirifer tornacensis de Koninck.
Spirifer spp.
Syringothyris principalis North.
Syringothyris cuspidata (Martin) mut. *cyrtorhyncha* North.
Camarotoechia aff. *mitcheldeanensis* Vaughan.
Modiola spp.
Naticopsis spp.
Phillipsia sp.
Bryozoa.
Psephodus.

The fossils are typical of the K_1 Zone of the South-West Province ; it is remarkable, however, that such forms as athyrids (*Cliothyridina roissyi*) and *Eumetria* have not been noted, while only one small fragment of a species of *Chonetes* has been found.

The spirifers are abundant, and include several species. *Syringothyris* is fairly common, whilst *Productus* and *Camarotoechia* occur in great numbers.

Near or at the top of the Crinoidal Limestone there occurs a few feet of rottenstone, very similar to that seen elsewhere in the Lower Limestone Shales, bordering the crop of the South Wales Coalfield.[1] This rock has not been seen in situ, but blocks are to be found immediately above the old workings on the southern side of the hill. The rottenstone is fossiliferous, and well-preserved casts and moulds of the following forms have been obtained :—

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[1] T. N. George, "The Carboniferous Limestone (Avonian) Succession of a Portion of the North Crop of the South Wales Coalfield": *Q.J.G.S.*, 1927, p. 64.

Avonia bassus (Vaughan).
Productus sp.
Schellwienella cf. *crenistria* (Phillips).
Syringothyris cuspidata (Martin).
Camarotoechia aff. *mitcheldeanensis* Vaughan.
Modiola sp.
Cf. *Parallelodon* sp.

(iii) *The Yellow Oolite.*

This division is sharply delimited from the underlying, the two rocks being in striking contrast as regards both colour and lithology. The Oolite is a very pure massive coarse rock, occasionally weathering to flags. The oolite grains vary in size, particularly in a direction perpendicular to the bedding; the largest are about 2 mm. in diameter. Occasionally the beds are ironshot or stained red, such staining being confined to the oolite grains, which are cemented together by à colourless mosaic of calcite crystals. Fossils are rare in the greater portion, but shelly bands occur and contain :—

Productus sp. nov. (*Productus* cf. *martini* Sowerby Vaughan).
Schellwienella cf. *crenistria* (Phillips).
Syringothyris cuspidata (Martin) mut. *cyrtorhyncha* North.
Camarotoechia aff. *mitcheldeanensis* Vaughan.
Myalina sp.
Modiola spp.
Other obscure lamellibranchs.
Fenestella sp.

The fauna contains species which are common to both K_1 and K_2, and no distinctive forms (such as *Avonia bassus* or *Spiriferina*) have been found, so that it is not possible to group this division in one or other of the subzones. Considerations of thickness and comparison with the main outcrop suggest, however, that the beds are of K_2 age.

Murchison [1] said that "The chief mass [of Limestone] is thick-bedded, compact, and sub-crystalline, of a cream colour and without fossils [this evidently refers to the Yellow Oolite]; but in some of the thinner beds on the southern face of the mountain, where they disappear beneath the cap of millstone grit, they become oolitic and contain a few organic remains—Productus, Terebratula, Corals, and Encrinites . . ." At present, the Oolite is well-exposed on the *northern* side of the mountain, where its oolitic structure is very apparent, and is almost entirely obscured by vegetation on the southern. No signs of his "Terebratula, Corals", have been seen; possibly what is now known as *Camarotoechia* he included in the forms he called Terebratula.

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[1] *Silurian System,* op. cit., p. 163.

Millstone Grit.

There is an abrupt change in lithology at the top of the Yellow Oolite, which is succeeded by a series of grits, quartzites, and quartz-conglomerates typical of the Millstone Grit. They are almost completely composed of quartz grains and pebbles (up to several inches across) cemented in a groundwork of quartz crystals. No specimens of Avonian rocks have been found in the Grit, though a few pellets of brown mudstone recall Old Red Sandstone types.

The thickness can only be approximately measured; Murchison said it is about 150–200 feet, which is a generous estimate. Rarely do the beds appear to outcrop in situ; the ground is for the most part strewn with scree material.

As to the age of the Grit, little can be said. No fossils have been found, except some obscure traces of plants, including a lepidodendroid form. It is probable, however, that the beds are of approximately the same age as those immediately succeeding the Limestone of the main outcrop, where the lower beds of the Grit are almost identical lithologically.

III. COMPARISON WITH THE BEDS OF THE MAIN OUTCROP.

The Lower Limestone Shales between Abergavenny and Blaen-Onnen present no constant sequence which can be traced in detail along the crop; they are a varied and varying group of shales, mudstones, and limestones of several types, including sandy and conglomeratic layers. It is not surprising therefore that the Avonian of Pen-Cerig-calch cannot be exactly compared with any particular section of the main outcrop. Only the lowest few feet (the *Modiola*-phase) can be definitely correlated, for although such a phase is not delimited in the Survey Memoir, Dr. Robertson informs me (in lit.) that at several places (e.g. Craig-y-cwm, Blorenge, Llangattwg) he was inclined to separate a basal shallow-water phase and refer it to K_m.

The Crinoidal Limestone may be compared with similar beds occurring at various horizons in the Lower Limestone Shale elsewhere in the neighbourhood, but the Yellow Oolite is remarkably peculiar. Oolitic limestones occur sporadically throughout the Shales, and grains are frequently observed in the more calcareous beds of the main outcrop, but such a rock, noteworthy in its purity, colour, and thickness, is quite unique. It evidently represents a very local development.

The succeeding Millstone Grit is obviously equivalent to the basal quartzites and quartz-conglomerates of the main outcrop, though it is possibly significant that it is rather more thickly developed.

It is interesting to note that in the short distance between Llangattwg and Pen-Cerig-calch the Carboniferous Limestone is reduced from over 300 feet to about 60–70 feet, and the development of the Limestone is comparable with the more distant Craig-y-cwm and Blorenge sections.[1] Even so, the denudation which preceded the deposition of the Millstone Grit proceeded a stage further on Pen-Cerig-calch than at the last-named places, and removed a further 30–40 feet.

It is uncertain to what extent the relative positions of the outcrops have been altered by subsequent earth-movement, but if the geographical relations of the various localities have not been considerably modified, then it would appear that the trend of the earth-movements which preceded the deposition of the Millstone Grit ran in a N.W.–S.E. direction.

Kent's Cavern. Mr. Northmore's Account of his Discoveries.

By F. Longworth-Dames.

In connexion with the recent excavations in Kent's Cavern, the following particulars relative to the discovery of the first organic remains by Mr. Thomas Northmore, F.S.A., of Cleve, near Exeter, in September, 1824, will prove of interest to many readers. They are given in a letter written by Mr. Northmore to the Editor of *The Panorama of Torquay*, 1832—Mr. Octavian Blewitt.

He was accompanied by his brother-in-law, Capt. Richard Welby, and two assistants (William Rossiter and John Ferris), and also by "an able draughtsman, Mr. Glendall, of Exeter". He made his visit to the Cave on the 21st September, 1824, with the double object of finding organic remains and ascertaining the existence of a temple devoted to the worship of Mithras. "Upon entering the cavern," he writes, "and being at the same time a novice in the art of exploring, I began to consider in what part it was most likely to find the expected treasures, and seeing a small recess in the left side, some way in the cavern, of a size sufficiently large to hold a large tiger, I began to dig therein through the stalagmitic covering, and in less than ten minutes I could not forbear exclaiming with joy—'*Here it is*'; and I pulled out an old worn-down tusk of an *Hyaena*, and soon afterwards, a Metatarsal bone of the *Cavern Bear*. About 20 or 30 other teeth and bones were the results of our labours on that day." The whole length of the cavern as it was at that time, was estimated by Mr. Northmore to be 657 feet. "The width and height of the cave continually varies, the former from 2 feet 3 inches to 71 feet; the latter from that portion of the cavern called the *oven*, where you are obliged to *creep* up to 18 feet."

"The organic remains discovered in this complicated cavern are principally those of *Rhinoceroses*, *Hippotamus*, *Elephant*, *Hyaena*,

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[1] *Abergavenny*, op. cit., p. 32.

Cavern-bear, *Elk*, *Tiger*, *Ox* (and, I believe, *Buffalo*), *Horse*, *Wolf*, *Dog*, *Deer*, *Sheep*, *Rabbit*, *Rat*, *Mouse*, and some others . . . I had the honour of being accompanied in some of my researches by various scientific gentlemen and others. Among whom I beg to mention the names of my relative, Dr. Greville (the botanist), Captain, now Admiral, Sartorius, Mr. Scudamore, Mr. Barker, the Rev. Mr. M'Enery, Mr. Henderson, Dr. Matthews, the Rev. Mr. Daniel, and last, but not least, the celebrated Professor of Oxford [Dr. Buckland], who kindly favoured me not only with his useful instructions how to proceed, but what carries more weight than precept, with his zealous and valuable example."

A few words relating to Mr. Northmore may be given here. He was born in 1766, graduated B.A. at Emmanuel College, Cambridge, in 1789, and M.A., in 1792. In the year 1805–6 he communicated to *Nicolson's Chemical Journal* particulars of his discoveries relating to the condensation of gases. He was a strong supporter of the rights of the American colonists in the War of Independence—and, in 1809, published *Washington, or Liberty Restored; a Poem of Ten Books*, which was also reprinted in Boston the same year. In one line he aptly described Washington as "He who Freedom gave to half the World". He died in 1851. A biography of his life is given in the *Dictionary of National Biography.*

Geological Notes on the Island of Dominica, B.W.I.

By Kenneth W. Earle, M.Sc., F.G.S.

Topographical.
Geological.
  1. The Older Volcanic Rocks.
  2. Marine Deposits.
  3. Later Lava Flows and Recent Deposits.
Recent Volcanic Phenomena.
Rock Types from Dominica.
Fossils from the Limestone Deposits.
General Observations on the History of the Lesser Antilles.

Topographical.

THE island of Dominica is situated in lat. 15° 20′ N., and long. 62° 30′ W., and lies almost midway between the French islands of Guadeloupe (on the north) and Martinique (on the south). In the northern channel the Antillean plateau is submerged to a depth of about 2,100 feet, but in the southern a deep embayment entering from the west reaches a maximum depth of 6,600 feet. Some miles to the south-east of Dominica, however, the sea floor rises to within 270 feet of the surface, while the Madiana banks, east of Martinique and north of Barbados, are submerged only to about the same depth. Lying as they do between the sedimentary parts of Antigua, Guadeloupe, and Barbados it would be interesting to ascertain, if possible, by boring, whether these banks are of a sedimentary nature

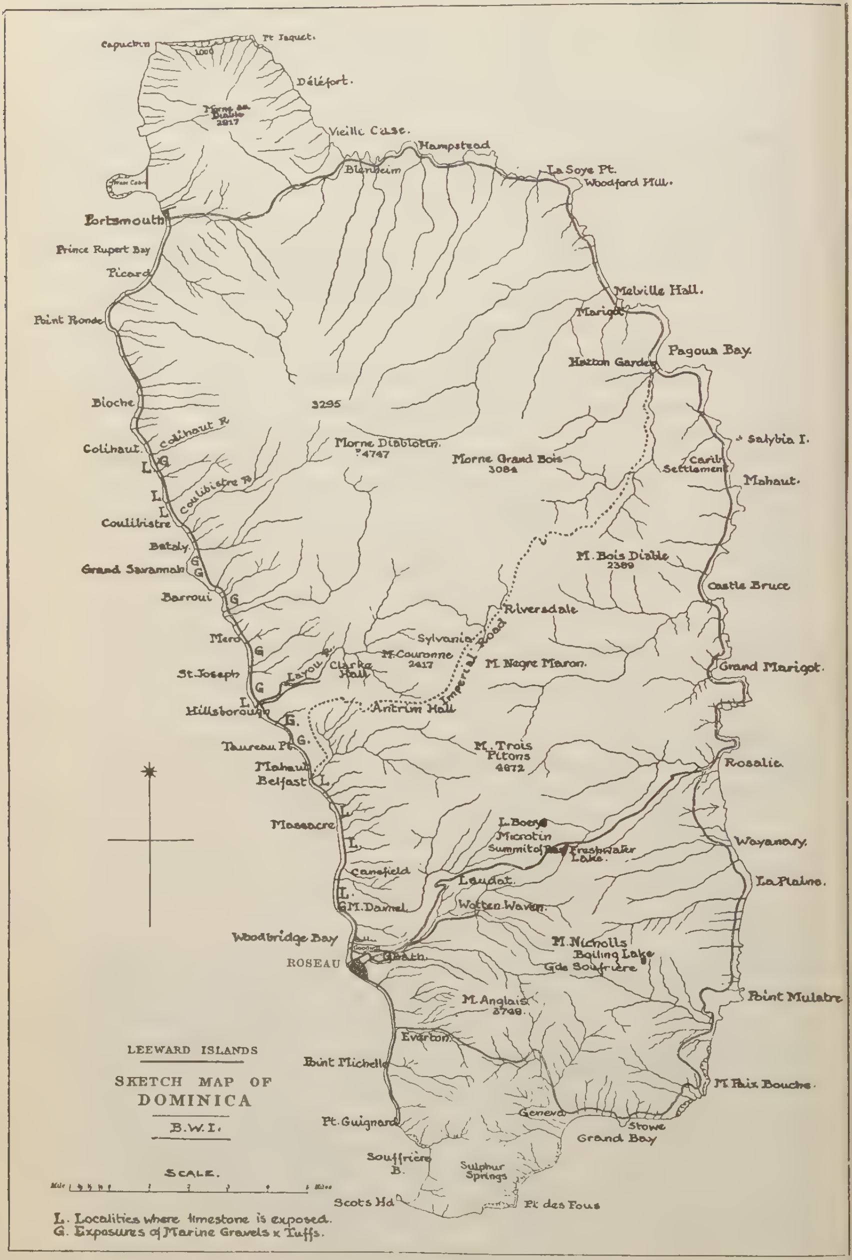

FIG. 1.—Sketch-map of Dominica, B.W.I.

in contrast to the volcanic nature of the main range of islands. On both the windward and leeward sides Dominica rises precipitously out of the sea, but this is more accentuated on the leeward side where within six or seven miles of the shore the sea bottom reaches a depth of over a thousand fathoms. The precipitous nature of the sea floor and the absence of any sort of harbour at Roseau—the capital—render anchorage even at favourable times a very precarious matter, and one of great difficulty and danger in rough weather.

The island has a maximum length of 34 and a maximum breadth of 15 miles, and is the largest of all the British West Indies, with the exception of Trinidad and Jamaica. It is exceedingly mountainous, and it would be a matter of considerable difficulty to find sufficient flat land to even lay out a short racecourse. It consists of a mass of volcanic ridges culminating in Morne Diablotin, 4,747 feet high,[1] with the Trois Pitons and other peaks but little lower. Almost everywhere round the coast these ridges terminate in steep cliffs, reaching a maximum height of 1,000 feet at the north end of the island. The only place with anything approaching a safe harbour is Prince Rupert's Bay at Portsmouth—the second "town" and situated at the north-west end of the island, and it is probable that this would have in the past taken precedence over Roseau as capital were it not for the vast mosquito breeding swamps behind the town.

The mountain ridges are everywhere dissected by ravines and gorges—often with vertical cliffs 300–500 feet high. One of the finest of these gorges is the Roseau Valley itself, terminating about 5 miles from the town in magnificent twin waterfalls, both well over 100 feet high. Visitors to Dominica are always told that there are 365 permanent rivers, one for each day in the year, as well as an inch of rainfall for every day in the year, and in neither case is the situation much exaggerated. In 1921 the highest recorded rainfall was registered at Lakeside (2,350 feet) (360·60 in.), and the average for twenty-seven stations was 104·48 in. Naturally, in the higher mountains where no records are available this is even exceeded. The destructive nature of such a rainfall can be well imagined; bridges are washed away, native dwellings swept into the sea, and "roads" destroyed or obliterated by hillslides, to say nothing of the damage to lime and cocoa estates.

Another very trying thing to travellers is the absence of roads. From Roseau it is generally possible, though not always advisable, to drive a car three to four miles up the Roseau Valley or southward down the coast (Point Michelle), 11 miles northward up the coast (St. Joseph and Clark Hall), or 12 miles up the Imperial Road into the interior of the island; for the rest the traveller must take to horseback or foot.

Between St. Joseph and Portsmouth, owing to the terribly rough nature of the track and the calmness of the sea most of the traffic is by water, but everywhere round the windward coast traffic is by land. There is a well-defined track connecting all the villages and estates on the windward coast, but it takes the form of a continuous and repeated zigzag up and down ridges from sea-level to 800 feet or more, and the track being composed entirely of red clay, travelling either on foot or horseback is a matter of the utmost tediousness, which is enormously exaggerated in bad weather. Across the island only three tracks exist, one from Newtown to Grand Bay, another from Roseau to Rosalie—crossing the ridge by a large freshwater lake at an altitude of 2,500 to 2,800 feet—and a third from Portsmouth to Blenheim.

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[1] Admiralty Chart reading. Recent ascents of the mountain have shown it to be considerably higher, probably 5,000 feet.

To the geologist, whose work takes him essentially off the beaten track, the difficulty of terrain is perhaps greater than to the planter. The headlands are all impassable by the beach and the whole of the interior, except in the comparatively few places where cultivation exists, clad in virgin forest to a large extent unknown and quite untracked. The river beds sometimes afford valuable geological information, but the gorge-like character of their banks generally makes them inaccessible or impassable for any considerable distance ; they cannot be negotiated by boat. The upper reaches of some of them such as the Layou River, the largest river in the island, have never been accurately mapped—the Admiralty Chart being largely diagrammatic and of little use for work in the interior.

In addition to the more ordinary phenomena of a tropical volcanic country Dominica has its own " show " sights. Foremost amongst these is the Boiling Lake, while there are numerous soufrières and warm and mineral springs, the exact number of which is perhaps not accurately known ; these will be further described later.

The population of the whole island, mostly Catholics, numbers 34,000.

GEOLOGICAL.

1. *The Older Volcanic Rocks.*

Geologically the island does not differ very materially from St. Kitts, the differences being chiefly of a topographical character due to differing atmospheric conditions in the two islands.

We can recognize in Dominica, as in St. Kitts, an older basement series of volcanic rocks, largely obscured and obliterated not only by more recent volcanic ejectamenta, but by the wholesale destruction of the parent rock by atmospheric weathering and decomposition. At intervals during the deposition of these later pyroclastic rocks coastal submergence took place, giving rise to current bedded tuffs of a distinctly marine character as well as raised beaches consisting of fossiliferous limestones of Pleistocene age. I have not recognized any of these sedimentary deposits at any great altitudes inland, and there is thus no evidence—as in Antigua—for an Oligocene submergence of the island. The only stratified rocks of any kind found in the interior were at Sylvania Waterfall on the Imperial Road, and consisted of a white chalky marl; this is situated right on the watershed just below an extensive swamp, and it is probably nothing more than a recently accumulated silt.

The oldest rocks are best seen along the coast sections, as there the attrition by the sea is more rapid than the decomposition of the rocks. In the interior, however, even when denuded of all newer accumulations, these rocks are found to be decomposed to a great depth into a bright red ferruginous clay. There is a fine section of this clay at the "Red Gully" on the Imperial Road, but it is of very widespread occurrence over all the interior and the windward coast. A more intimate knowledge of the island reveals the fact that this clay has a definite distribution; it does not occur north of Vieille Case or south of Grand Bay, and while it reaches almost down to sea level on the windward coast, is seldom found below 1,000 feet on the leeward. Its occurrence is, in fact, confined to the areas of most intense rainfall, and it affords an interesting comparison with the dry friable sandy soils of St. Kitts, formed by decomposition under moderately dry and cultivated conditions. Comparison of these red soils with typical Indian laterites is made below.[1]

COMPOSITION OF 20 PER CENT HYDROCHLORIC ACID EXTRACT OF SOIL, EXPRESSED AS PERCENTAGE OF DRY SOIL.

	Average of six Central Upland Estates.	Average of five Windward Coast Estates.	Average of six Leeward Coast Estates.	Typical Indian Lateritic Soil.
Insoluble residue	51·10	59·00	71·37	76·86
Soluble Silica	0·27	0·38	0·11	—
Al_2O_3	9·40	11·11	6·18	8·84
Fe_2O_3	10·23	10·68	8·83	10·09
MnO	0·59	0·45	0·05	—
CaO	0·37	0·33	1·34	trace
MgO	0·09	0·08	0·24	0·77
K_2O	0·10	0·08	0·10	0·00
Na_2O	0·17	0·26	0·42	0·17
Cl	0·005	0·01	0·01	—
SO_4	0·09	0·05	0·07	—
P_2O_5	0·08	0·09	0·10	trace
Combined water	11·31	7·88	5·16	2·87
Humus	7·14	2·25	2·36	
$CaCO_3$	0·34	0·15	0·28	0·27

The analytical figures show that the mean percentage of total acid soluble matter, which includes the hydroxides of aluminium and iron, may be definitely correlated with the intensity of rainfall, for in the leeward coast samples there is much more insoluble matter and considerably less aluminium and iron hydroxides than in the upland samples. Lateritization has apparently not gone on so completely in the drier regions as in those of high rainfall.

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[1] Hardy, *v.* Bibliography.

The basement rocks, where exposed round the coast, as, for instance, at Point Michelle, Taureau Point, etc., do not differ essentially from the basement rocks of St. Kitts. They are typically andesites, characterized by pyroxenes of either rhombic or monoclinic habit or both, constituting them augite or hypersthene andesites according to the relative preponderance of the two minerals in question.

They are generally grey-white or pink in colour, and besides showing patches consisting of the more basic parts of the magma, sometimes enclose finer grained patches of rock, a sort of corrosion rim showing the line of contact. By their kaolinization and decomposition these rocks' give rise to a grey earthy deposit known as "Tarish", which is used extensively for mixing with lime to make rough mortar. A banding of the ferromagnesian minerals is sometimes visible.

Rocks of this character are exposed at intervals all round the coast from Point Jacquet to Grand Bay, and from West Cabri to Stowe Head, where the cliffs are accessible.

No age can be assigned to these rocks with any certainty, but by analogy with St. Kitts and Antigua it is probable that they belong to the earliest Tertiary (Eocene) times.

Associated with, or possibly later than these hypersthene andesites—but quite impossible to map separately in a country of the nature of Dominica—we have, as in St. Kitts, black vesicular basaltic rocks characterized by a basic felspar and olivine with or without a pyroxene. Rocks of this character have been collected at the Grande Soufrière, up the Imperial Road, in the Layou Valley, and elsewhere. At Rosalie jetty rock of this character can be seen bedded in sheets two or three feet thick with coarse angular volcanic breccia and dipping 20–25 degrees east.

Two perpendicular dykes of vesicular doleritic andesite traverse the series at this point, a similar phenomenon being visible on the beach at Salybia.

These rocks are all liable to be jointed in columnar basaltiform fashion, and occasionally show jointing resembling a pseudo-dip. Spheroidal structure is common as well, indicating incipient decomposition. Occasionally there is a pseudo-flow structure in the andesites, the darker rock constituents being arranged in parallel fashion or drawn out into "eyes" in the more acid ground mass. They frequently contain iron pyrites as an important accessory mineral which can sometimes be plainly seen with the naked eye.

Everywhere in the interior these basement rocks are obscured by later volcanic ejectamenta in the form of breccias and conglomerates. Generally speaking these are only loosely cemented, the matrix decomposing—in the wetter parts of the island—to a red clay, with residual boulders of the unaltered rock. In spite of the usually loose cementation of this deposit, it is more stable than the friable sandy soils of St. Kitts, and the more intense rainfall produces in the larger rivers cañon-like gorges, quite unlike the V-shaped ravines of St. Kitts. It is generally quite impossible to cross a large river valley from ridge to ridge, so that a tremendous amount of time is wasted by having to return on one's tracks down to the valley mouth.

In the drier parts of the island denudation of these rocks is mechanical rather than chemical, and anything more rugged and stony than the track from Pt. Jacquet to Capuchin or from Picard to Layou (leeward coast) it would be hard to find.

Round the coast it is often very difficult to separate these deposits from the marine gravel and boulder accumulations. At places, e.g. at Rosalie jetty and at Vieille Case, the deposit is a typical volcanic agglomerate, consisting of entirely angular blocks of volcanic rock cemented into a firm mass; but at times even in the interior there is a very marked rounding in the constituent boulders, which may reach any size and give to the country an aspect not unlike a heavily drift covered district of northern England.

Frequently in the coastal cliffs a rough stratification is visible, but this is always radially from the interior of the island.

The included boulders in these deposits consist of fragments of the basement rocks, grey-white, green, or purple andesites, with a proportion of the black basaltic rocks before mentioned. A little flint and jasper occasionally occur and here and there lumps of kaolin.

It will be seen later by the relationship of these conglomerates to the limestone deposits that the deposition did not take place at one epoch only, but went on spasmodically, with intervals during which subsidence took place, followed by deposition of pure marine limestones and succeeded in turn by renewed outbursts of volcanic ejectamenta up to a late Pleistocene period.

Writers in the past[1] have tried to recognize a number of different conglomerates and tuffs of marine character, but nearly all have based their classification on coastal sections and those easily accessible from town. It is probable that much of this ejected material was hurled into the sea and suffered erosion and partial stratification before subsequent elevation, so that we have accumulations deposited both subaerially and wholly or partly submarine in close proximity and almost impossible to separate. I only propose to treat as marine such deposits as show marked rounding of the included boulders, or marked stratification or current bedding, or such as are of a fossiliferous nature.

These are the Roseau and related tuffs, the gravel formations of Morne Daniel and the Grand Savannah and the raised limestone deposits of the leeward coast.

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[1] Particularly Spencer, *v.* Bibliography.

2. *Marine Deposits.*

The *Roseau Tuffs* are exposed at the back of the town on Morne Bruce and up the Roseau Valley. One of the best sections of them is close to Emshall House on the road to the Power Station.

These tuffs consist of fine grained gritty particles with bands of pebbles and interspersed with brown ferruginous sands. The pebbles, which are nearly all small, water-worn, and ellipsoidal in shape, occur in bands terminating abruptly or are scattered irregularly through the mass. Splendid current bedding and unconformity between the individual layers is visible. The strata are overlain by gravels of the Morne Daniel type up to a height of 300 feet. They have been elevated to dip slightly seaward, the surface of the land through which the Roseau River has cut its valley forming a well-marked sloping terrace fronting the mountain ranges. These tuffs are undoubtedly of marine origin, and of comparatively recent date.

The *Gravel Series* is seen at many points up the leeward coast, as far as Colihaut, though their disconnection and variation make correlation very difficult.

At Morne Daniel—2 miles north of Roseau—there is an exposure showing 50 feet of marine gravels at the foot of the cliff. This is composed of rolled and water-worn andesitic pebbles up to 1 or 2 feet in diameter. The upper boundary of this gravel deposit is very irregular, and deposited in pockets in the gravels is the fossiliferous Morne Daniel limestone.

Between Paz Farm and Hillsborough a gravel bed with well-rounded or subrounded pebbles occurs up to an altitude of 100 feet, though the higher part of the cliff is chiefly composed of fine-grained ashes and tuffs. Stratification is exhibited by the banding of the coarser pebbles and the consequent erosion of the finer grained intermediate ash beds. Similar beds are seen north and south of St. Joseph, highly false bedded and dipping in all directions. Near Barroui fine-grained brown gravels dip 10–12 degrees north.

At the Grand Savannah—one of the driest spots in the island and nothing more than a blazing hot, scrub-covered desert—two gravel series are recognizable, separated by an unconformity. The lower 20 feet are composed of yellowish gravel, upon the denuded surface of which is another of grey gravel with some angular material, which, on approaching Batalie, reaches a maximum thickness of about 40 feet.

Gravels are again seen in the cliff underlying limestone just south of Colihaut.

The unconformable relation between these two beds is also seen in the high cliff section between Colihaut and Coulibistre. Here the relation to the limestone is also seen. Immediately overlying the limestone—dipping at 10 degrees—is a bed of well-stratified brown gravel, with included pebbles of andesite, rarely exceeding 3 inches in length. Most of the material is subangular, but there are also fine layers—a few inches thick—of quite fine ashy material. These aggregate 20 feet in thickness, and dip markedly 10–15 degrees south. They are overlain unconformably by grey gravel 30–40 feet thick, which dips from 0–5 degrees south. These grey beds vary very much in coarseness, but are quite distinct from the again overlying agglomerates which occupy the top 20 feet of the cliff and contain large angular and subrounded boulders. A little further south this latter agglomerate is succeeded by more brown tuffs, almost horizontal, then more agglomerate to the top of the cliff.

Between here and Coulibistre are more fine-grained false-bedded tuffs—almost approaching sandstones at times—dipping south-south-west. Also boulder beds with an irregular dip but generally about 10–15 degrees south, and occupying pockets throughout the series are beds of limestone with fossils.

It is thus evident that the deposition of all these gravels, ashes and limestone beds went on more or less simultaneously, varying from time to time according to the stability of the land and the amount of volcanic detritus accumulating either from volcanic outbursts or natural denuding agencies. The age of these collective deposits as judged from the fossil contents of the limestone cannot be placed further back than the Mid-Pleistocene epoch.

The gravels are also seen in the cliff *under*-lying limestone beds just south of Colihaut, but they have not been noticed north of this point, nor in the windward coast with the possible exception of the cliff at La Plaine, which may be in part of submarine deposition.

The distribution of the *Limestone* corresponds with that of these marine gravels, as it only occurrs between Colihaut and Roseau and in no place—so far as is known—in the interior or on the windward side of the island. As before mentioned, its relationship to the gravels is penecontemporaneous, the limestone always either occupying hollows and pockets in the midst of the gravels themselves or overlying the gravels where the series is incomplete (as at Morne Daniel).

Immediately south of Colihaut it consists of a yellow marly bed overlain by white crystalline limestone; the deposit is both over- and underlain by angular agglomerate and dips 10–15 degrees north, thickening considerably towards the south. It is evident that volcanic activity went on during the deposition of this limestone, as in many places angular volcanic detritus occurs in the limestone itself as well as "eyes" of ashy material drawn out longitudinally as if by wave action.

The next headland south shows a considerable thickness of well-bedded (horizontal) limestone and marl. This is in marked contrast to the usually unbedded character of these limestones. The huge blocks occurring on the coast are considerably indurated by the sea, but in the cliff itself the rock is soft and powdery. There are also included pebbles of markedly spheroidal volcanic material. Fossils are very abundant here, and include lamellibranchs, corals, calcareous algae, echinoids, and gastropods.

Where the path again reaches the beach (going south) the limestone is full of large compound corals and dips about 10 degrees towards the beach.

Between here and Coulibistre, as before mentioned, the limestone does not form continuous beds, even shifted by faulting, but consists of lenticular intercalations of a wedge or pocket shaped character at different levels in the gravel series and represents episodes of submergence free from volcanic ejectamenta. It generally, however, contains volcanic material, sometimes approaching a pebble bed with a limestone cement. Just north of Coulibistre the telephone is fixed to a 30 feet cliff of limestone, containing lamellibranchs and large colonies of corals.

From here southwards the limestone is not noticed till reaching the Layou River. Between the Layou River and Roseau six exposures of it occur, all of them, excepting that at Morne Daniel, being of small extent.

(1) In fallen blocks from the top of the cliff at the mouth of the Layou River—not visible *in situ*.

(2) Between Paz Farm and Mahaut. 10–12 feet exposed for 20–30 yards by roadside ; overlying gravel.

(3) Bluff at angle of road immediately south of Belfast. Two or three isolated masses by roadside at sea level, and one in the middle of the beach.

(4) Small bluff at angle of road near Massacre Church.

(5) Just north of Checkhall Bridge, small terrace 40 feet high a little way inland behind a cultivation.

(6) Morne Daniel. Here 30 feet of limestone occur occupying hollows in a gravel formation consisting of corals (sometimes 3 feet long and in the position of growth), gastropods, and lamellibranchs. The gastropods usually occur in the fine-grained gritty basement beds, and echinoids were not recognized.

These limestone deposits resemble very closely the Brimstone Hill (St. Kitts) beds and are undoubtedly of Pleistocene age.

Wherever they occur along the roadside, they have been quarried into caves for road metal, and afford the only tolerable stretches of road north of Roseau at all.

A complete list of the fauna from the limestone deposits of Dominica, so far as it is known, is given on page 184.

3. *Later Lava Flows and Recent Deposits.*

There is evidence at various points in Dominica that the marine formations above described were not the latest rocks deposited in the island, but that there were subsequent lava flows of a type very similar to the earlier ones.

Between Colihaut and Coulibistre the marine gravels and tuffs containing pockets of limestone are overlain by 10–15 feet of massive cleaved and vertically jointed lava. In the hand specimen this is a coarse grey gritty rock with felspar phenocrysts and rusty iron granules. Under the microscope the rock is seen to be an andesite, consisting of two generations of (labradorite) felspar with small quantities of augite and hypersthene. The rock, therefore, corresponds closely with the earlier volcanic rocks of the interior.

At Coulibistre the river gorge is capped on both sides by this lava, as also is Coulibistre Hill, where the seaward slope of the lava corresponds with the slope of the hill. At Grand Savannah the gravels are also capped by lava which reaches the sea at the south side. It is probable that the peculiar fan-like slope from the interior so conspicuous in the Grand Savannah, as also its arid character, are largely due to this later flow of lava.

Similar vertically jointed lavas are seen in other river gorges to the south, particularly in the Layou River—capping the gravel and agglomerate deposits. They are also very conspicuous as seen from the sea at Pirates Cliff, Pt. Guignard, between Roseau and Souffrière.

These, then, are probably the latest rocks exposed in the island, with the exception of small deposits of ash from the active soufrières in recent times and such fan-shaped coastal flats as that on which the town of Roseau is built, which represents nothing more than the delta of the rapidly eroding Roseau river.

The beaches of Dominica should be mentioned. In all exposed localities and in most places on the leeward coast as well these consist entirely of large ellipsoidal boulders of andesite, etc., derived from the conglomerate and gravel formations. In one or two sheltered bays, particularly in the neighbourhood of Layou and St. Joseph, where a large amount of silt is brought down by the Layou River, this gives place to a black mineral sand composed chiefly of finely comminuted fragments of the ferromagnesian minerals derived from the volcanic rocks. In two places only—Scots Head, the extreme southern point of the island, and La Soye Point, on the north-east coast—is there yellow sand. In this latter locality it is a coral sand derived from the coastal coral reef which extends from La Soye Point to Caribishee and Hampstead.

RECENT VOLCANIC PHENOMENA.

Dominica is the only British island of the Leeward Group which shows any evidence of volcanic activity at the present day. This activity displays itself in the famous Boiling Lake, and in numerous solfataras throughout the island.

The Boiling Lake is situated in the Grande Soufrière Valley, some 5 or 6 miles due east of Roseau under the lee of Morne Nicholls. Visitors to the lake generally stay overnight at Laudat, at the head of the Roseau Valley; if this be done the journey through the forest is not an exhausting one to anyone inured to rough, rocky, and excessively muddy bush tramping. The track is well defined and the journey, which must be performed on foot, takes about 2½ hours to the Grande Soufrière and another three-quarters to one hour to the Boiling Lake itself. (Fig. 2.)

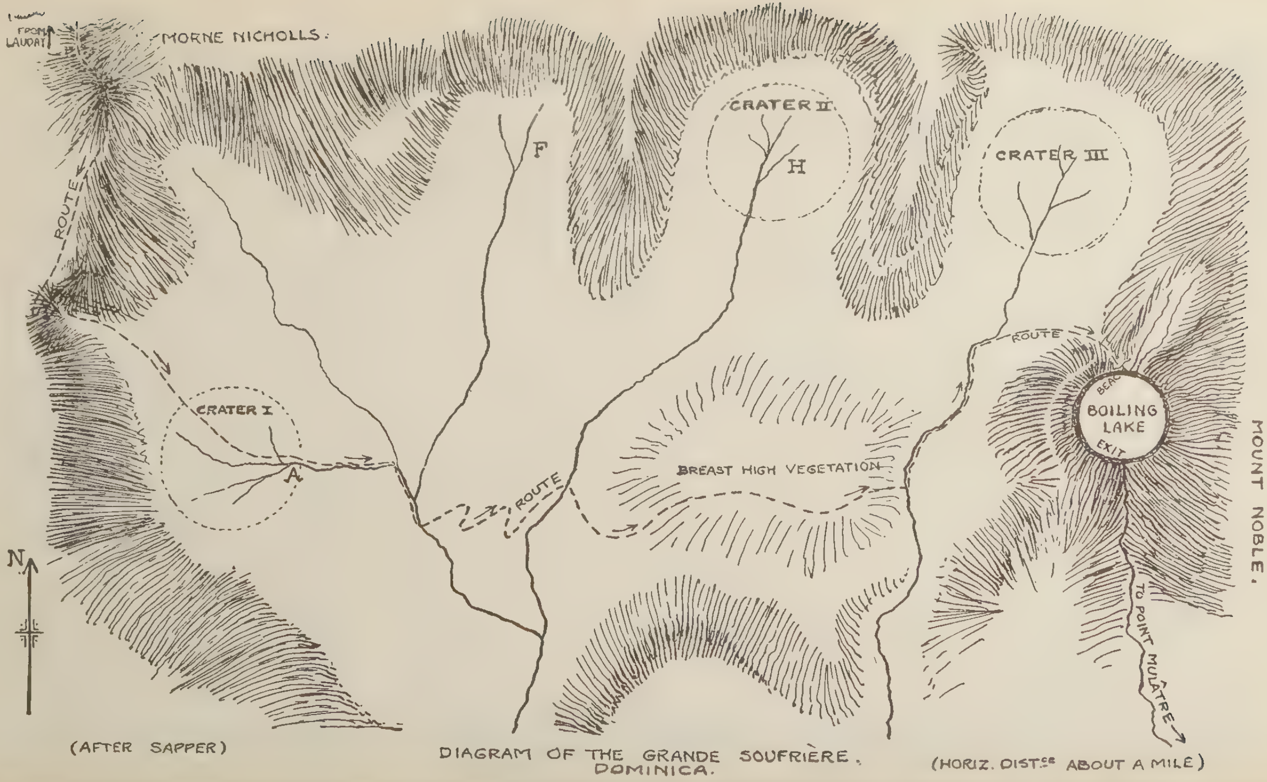

Fig. 2.—Diagram of Grande Soufrière, Dominica.

Passing over the crest of Morne Nicholls—from which lovely views are obtained—a short scramble brings one out of the deep forest and overlooking the "Valley of Desolation". The Grande Soufrière occupies a gigantic amphitheatre, flanked all round by lofty mountains, and consists, apart from the Boiling Lake itself, of at least three separate "craters" feeding three separate rivers, all flowing into Point Mulâtre River. The whole of the amphitheatre is free of all vegetation except low-growing bush, creepers, and vines, and in the "craters" themselves many tree trunks can be seen burnt and blasted by the poisonous fumes.

A very steep scramble over red clay down the western slope of the amphitheatre brings us to the first and most imposing soufrière. The diameter of this is about 200 yards, and within this area are numerous small basins from which boiling water is being thrown up. Dense clouds of steam are thrown to a considerable height in the air, and though these consist chiefly of water vapour there is an admixture of sulphurous and other gases and it is not wise to linger in the steam itself. Two small ponds of boiling water occur, all the water flowing down these streams being milky in colour owing to the suspended sulphur. When the soufrières are very active this milky colour is even noticeable miles away where the river enters the sea at Point Mulâtre. The ejection of steam is accompanied by considerable noise, and may be exactly likened to a blast of steam from a locomotive. Sapper, who took the temperatures of several of these springs, found them to vary from 45 degrees C. at H to 92 degrees C. at A and 95 degrees C. at F, the highest temperature recorded. All these soufrières undergo considerable seasonal variation, both in temperature, intensity, and in the location of the various vents.

The floor of the soufrière is a fairly stable crust of loose rocks, consisting chiefly of andesite, which becomes bleached by the rising vapours into a white or yellowish crumbly clay, in which, however, the less easily corroded crystals may still be recognized *in situ*. At the same time sublimates of sulphur or of chlorides are formed, while the sulphuric acid attacking the lime of the silicates gives rise to abundant crystalline gypsum. Silica is deposited in lesser degree from some orifices in the form of sinter or chalcedony and alum, travertine, kaolin, etc., are also formed. It is not easy to collect good crystals of sulphur, though it forms encrustations everywhere. Small mud volcanoes also occur, owing to the escape of gas and steam through liquid mud derived from the decomposition of the lavas and tuffs.

Craters II and III are less imposing repetitions of Crater I, and do not call for special description.

The journey from Crater I to the Boiling Lake is perhaps the most trying of all, as the route lies either through breast-high tangled vegetation or along the beds of the streams. In the latter case considerable care must be exercised in springing from one slippery boulder to another, as the water in all these streams, if not actually boiling, is unpleasantly hot. It is distinctly astringent to the taste.

The Boiling Lake, on arrival, presents a somewhat terrifying spectacle. It consists of a cauldron of water hemmed in by cliffs 50–60 feet high on every side, except for two deep gullies, one at the north end where small streams feed it, and one cleft in the cliff wall at the south end whence the water escapes into the main river below. There is a small beach about 3 feet above the water-level at the north end, which is accessible to photographers and other venturesome spirits—but not to negro guides!

The diameter of this cauldron is about 50 to 60 yards, and the depth of water said to be about 5–10 feet. By a local inhabitant who actually witnessed the phenomenon, I was told that at times the lake entirely empties itself by a central underground orifice and fills again in the course of half an hour. It is possible that it was in one of these episodes and during the subsequent ejection of carbonic acid gas fumes that an English visitor and a negro guide who went to his assistance met with their deaths by suffocation in 1901.

When the lake is full, as I saw it, the water is very black in colour, and has on the surface a distinctly oily film with bubbles of gas or steam 3–4 inches across floating on it. Practically the whole time the walls of the lake and the surface of the water are obscured by steam, and it is only with the utmost care and patience, and favoured by the best climatic conditions, that a good photograph can be obtained. This steam did not appear to be sulphurous, but when blown by the wind is intensely hot. The surface of the water is hardly ever still, intermittent ebullitions of boiling water taking place from various foci every 20–30 seconds. At approximately two-minute intervals there are more important eruptions from a roughly central point, consisting of an upheaval of water some 10 feet in diameter and 3 feet in height.[1] This is accompanied by a dull thunderous roar and dense volumes of steam. There is, in fact, an almost permanent underground rumble. The waves extend in circular ripples to the margin of the lake, but seem to have little effect on the height of the water level. The temperature of the water at the exit of the lake as recorded by Sapper was 87–88 degrees C.

In January, 1880, a violent eruption took place here, large portions of the mountain side being blown away and the town of Roseau being wrapped in darkness throughout the day by the clouds of ash which fell everywhere. Fortunately there was no loss of life. "In 1906 a violent earthquake took place. A fortnight after columns of boiling water from several of the springs rose to a height of 8–10 feet. The water flowing from the springs was at boiling point, and was of the colour and thickness of stone-coloured paint, whereas under ordinary conditions the water from the springs is quite pure."[2]

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[1] Sapper says the water reached a height of 2 metres at the time of his visit.

[2] Symington-Grieve, *v.* Bibliography.

Other soufrières occur at Ravine D'Or (Layou Valley), Morne au Diable (Portsmouth), Laudat and Souffrière Villages, and Wotten Waven. All of these are insignificant besides the Grande Soufrière, though the Wotten Waven springs are quite numerous and besides a few violent fumaroles also display small mud volcanoes. These latter springs are practically within motor drive from Roseau, and are invariably visited by tourists. In addition to these, there are other warm springs (e.g. the stream crossing the Rosalie "road" just above Laudat), the complete number of which is probably not precisely known.

The Freshwater Lake (2,350 feet), near the top of the pass between Roseau and Rosalie (2,600 feet), probably occupies the site of an extinct crater, as also does the less well-known Boery Lake, a mile or two to the north under Trois Pitons.

Although there is, I believe, no record of volcanic outbursts in the British Leeward Islands in historical times, there is no doubt that these solfataras act as safety valves to volcanoes which can hardly be considered entirely extinct. It is a curious fact, however, that in the terrible catastrophe of 1902 when St. Pierre was destroyed by the eruption of Mt. Pelée, no sympathetic disturbance was noticed in the Dominican Grand Soufrière, though it cannot be much more than 30 miles distant, whereas St. Vincent, very much farther away from Martinique, was in eruption at the same time with disastrous results.

ROCK TYPES FROM DOMINICA.

Index Letter.	*Rock name.*	*Locality.*	*Remarks.*
A.	Algal limestone.	Coulibistre Cliff.	Pleistocene.
B.	,, ,,	,, ,,	,,
C.	Augite hypersthene andesite.	2½ miles up the Layou River.	—
K.	Hypersthene basalt.	Grande Soufrière.	Pyritous rock.
M.	Hypersthene basalt.	Road-side, Antrim Hall.	—
P.	Augite andesite.	Taureau Point.	—
Q.	Andesite.	Colihaut Cliff.	Overlying the limestone.
S.	Hypersthene andesite.	Layou Valley.	—
T.	,, ,,	River Laurient, Riversdale.	
CC.	Basalt.	Stowe beach.	Hypersthene, augite, and olivine.
DD.	? Basalt.	Near Power Station, Roseau Valley.	Hypersthene, augite, and olivine.
EE.	Basalt.	Rosalie Jetty.	Bedded lava.
FF.	Doleritic andesite.	,,	Dyke rock.
GG.	? Basalt.	2½ miles up the Layou valley.	No ferromagnesian minerals.
HH.	Hypersthene basalt.	La Soye Point.	Junction of porphyritic rock with microcrystalline.

Fossils from the Limestone Deposits at Coulibistre and Morne Daniel, Dominica.

Corals.

E. *Agaricia* sp.
S. *Eusmilia aspera.*
S. *Favia ananas* Lam.
S. *Isopora muricata* Linn.
E.S. *Manicina gyrosa* Ell. and Sol.
E.S. *Orbicella annularis* Ell. and Sol.
E.S. *Orbicella cavernosa* Linn.
E.S. *Siderastraea siderea* Ell. and Sol.

Calcareous Algae.

E. *Archaeolithothamnion ? episporum* Howe.

Mollusca.

E. *Arca candida* Gmel.
E. *Cardium* sp.
S. *Cardium subelongatum* Sow.
S. *Cassis decussatus* Linn.
S. *Cassis flammeus* Linn.
E. *Codakia imbricatula* Adams.
S. *Conus testudinarius* Mart.
E.S. (*Cyclo*) *Tellina fausta* Sol.
S. *Cypraea cinerea* Linn.
E.S. *Cypraea exanthema* Linn.
S. *Dolium pennatum* Mart.
S. *Glycimeris pectinata* Lam.
S. *Glycimeris undata* Lam.
E. *Hemitoma* (*Patella*) *imbricata.*
E. ? *Latirus* sp.
E. *Lima* (*Ctenoides*) *scabra* Born.
S. *Lithodomus cinnamomeus* Lam.
S. *Lucina aurantia* Desh.
E.S. *Lucina* sp.
S. *Lucina tigria* Linn.
S. *Lutricola interstriata* Say.
E. *Mussa* sp.
S. *Natica caurena* Lam.
S. *Natica mammila* Linn.
E. *Natica* sp.
S. *Neritina punctulata* Lam.
E. *Ostrea* sp.
S. *Petricola robusta* Sow.
S. *Plicatella cristata* Lam.
S. *Pusio articulatus* Lam.
S. *Ranella cubiana* D'Orb.
S. *Spondylus coccineus* Lam.
E. *Spondylus echinatus* Mart.
S. *Tellina fausta* Sol.
S. *Tellina interrupta* Wood.
S. *Triton pilearis* Linn.
E. ? *Trivea vitrea* Gask.
E. *Voluta* sp.
S. *Turbo pica* Linn.
S. *Venus cancellata* Linn.
S. *Venus paphia* Linn.

Echinoid fragments.

S. Listed by Spencer, loc. cit. E. Author's collection.

General Observations on the History of the Lesser Antilles.

Anyone looking at a map of the Windward and Leeward Islands will be immediately struck with the fact that the main chain of islands aligns itself in an arc running from Saba on the north to Grenada on the south, and that this arc is concave towards the east. It is flanked on the west side by outposts such as St. Croix, and on the east side by those of Sombrero, St. Martin, St. Bartholomew, Barbuda, Antigua, Marie Galante, and Barbados.

It has further been recognized by even the earliest writers that the main arc is composed of islands almost entirely volcanic in origin, while the western and eastern outposts are composed of islands either wholly sedimentary or partly sedimentary and partly volcanic. Nor is it difficult to interpret this geological distribution if we consider the Lesser Antilles to have originated as a chain of submarine volcanoes initiated in earliest Tertiary times along a line of weakness which has been in a state of more or less complete inequilibrium ever since.

The extreme northerly members of the group, represented by St. Martin, Antigua, and possibly St. Croix appear to have reached stability as far as volcanic activity is concerned, in Eocene times. The piling up in Grenada of volcanic agglomerates on fresh water tuffs which have been intensely folded in an east and west direction indicates that some at least of the islands did not settle down till Miocene times. The up-ending of limestones of Pleistocene age in St. Kitts by the adventitious cone of Brimstone Hill indicates comparatively recent volcanic activity in that island.

But, for the most part, the northern and southern elements of the arc appear to have reached a state of comparatively stable equilibrium at the present day, volcanic activity being represented in those islands by nothing more than warm springs and small solfataras.

The central members of the group, however, represented by Dominica, Martinique, and St. Vincent represent the foci of maximum volcanic activity and cannot be said to have ever achieved stability even up to the present day. Dominica and Martinique represent, in fact, the still suppurating sores in a wound otherwise healed.

Some biologists have postulated the continuity of the Antillean continent in Pliocene times from North to South America. Others have pointed out that a rise in level of some 6,000 feet in ocean level would unite all the islands from Saba to Grenada and would even attach them to Barbados and South America. The islands themselves are considered to have been separated from one another by subsidence or by block-faulting in late Miocene or early Pliocene times, or by some process of "drift" analogous to that postulated by Wegener. Wayland Vaughan says[1]: ". . . there is no known geological evidence against a late Miocene or early Pliocene connection from Anguilla to South America."

But what is the evidence in favour of it?

The biological evidence is admittedly inconclusive,[2] and in the writer's view the bathymetric evidence is rather against the theory than in favour of it. The only possible indication—and that a very speculative one—of faulting on a large scale seen by the author was the northern coast of Dominica. This runs in a perfectly straight line for 2½ miles, and reaches a height of 1,000 feet in one sheer cliff.

The stratigraphical evidence, for what it is worth, also seems to the writer to be against the view. There is no indication at the present day that the volcanic piles were forced up through a sagging or rising continent of earlier age, nor of any widespread submergence before Pleistocene times. Why, therefore, should we postulate widespread elevation?

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[1] Loc. cit., p. 627.

[2] For further evidence on this point see Davis (Bibliography) and the author's Report on the Geology of Anguilla, published by the Crown Agent for the Colonies.

Marine Eocene deposits are confined to Antigua and St. Bartholomew, and even these are not of great importance. Marine Oligocene or Miocene deposits are developed in Anguilla, Tintamarre, ? Marie Galante and Grandterre (Guadeloupe)—which I did not visit—and probably Carriacou.[1] This latter island is a very important locality, and deserves more attention than it has received in the past. The fact that marine pre-Miocene strata reach an altitude of 1,000 feet in Antigua indicates very pronounced subsidence in that locality in early Tertiary times, and to the writer's way of thinking there is much more evidence for a Leeward Island continent than for an Antillean continent *in toto*. In Oligocene times there certainly seems to have been sea connection between the Leeward Islands and Guadeloupe and Carriacou, followed by elevation sufficient to raise the strata a hundred or two feet above the present sea-level.

That very extensive submergence took place in Pleistocene times is shown by deposits of marine limestones containing corals in Barbados (800 feet), Grenada (600 feet), Dominica, Montserrat (the two latter at but little elevation above sea-level), Statia (900 feet), Cuba (1,000–1,100 feet), and ? St. Kitts (1,150 feet). The deposition of these beds would necessitate a subsidence of at least 7,000 feet to establish the Pliocene continent demanded by believers in that theory. That undoubted warping has taken place along the previously established line of weakness is shown by the fact that the limestone deposits in Dominica are all situated along the leeward coast.

But the whole subject is fraught with difficulties, difficulties which are only increased if we include Trinidad and Barbados in our calculations. From what the author saw of Trinidad between steamer connections it appeared to present a set of crystalline schists folded in an east and west direction and comparable in many ways with the Virgin Island complex. If the northern range of Trinidad should be found comparable tectonically with the Virgin Islands and South America, the Lesser Antilles appear to be a misfit of Tertiary volcanoes along a line of weakness at right angles to a major set of igneous complexes which the author believes to be of Palaeozoic or Archaean age.

On the other hand the metamorphic series in Trinidad is overlain by a series of Tertiary strata which have no counterpart in the Virgin Islands or the Lesser Antilles. Nor is there anything analogous to the Anegada channel separating the Lesser Antilles from Trinidad and South America.

Finally Barbados is an aberrant apparently from all other known West Indian islands.

In recent years an enormous amount of highly detailed work has been done by the geological surveyors to the various oil companies operating in Barbados and Trinidad, and in the interests of pure geology it is of the utmost importance that they should co-operate to produce a composite geological map, together with their views as to the history and age of the strata and earth-movements in the two islands.

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[1] K. W. Earle, *Geological Survey of Grenada and the (Grenada) Grenadines.* Govt. Printing Office, St. George's, Grenada, 1924.

The utter impossibility of correlating—in the present state of our knowledge—the pre-Pleistocene deposits of Trinidad and Barbados with the Lesser Antilles would seem to the author to be another argument in favour of the latter having preserved their separate entities as an archipelago from the time of their inception, apart from local submergences and elevations which did not acquire any widespread importance south of Guadeloupe till Quaternary times.

(The whole of the above had been written before the author had access to Professor Morris Davis's book *The Lesser Antilles.* As Professor Davis and myself approach the subject from the different aspects of geomorphology and pure geology respectively, there can be little contentious between us. But I consider the last 25 pages of his book give one of the best and least biassed reviews of the Antillean continental theory that has yet appeared in either continent.)

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REVIEWS.

FIFTY YEARS' PROGRESS IN GEOLOGY, 1876–1926. Johns Hopkins Studies in Geology, No. 8. pp. 161. Baltimore: The Johns Hopkins Press, 1927. Price $1·50.

IN the year 1926 the great Johns Hopkins University at Baltimore, Maryland, celebrated the fiftieth anniversary of its foundation by various conferences and other functions. The present publication is a "Festschrift", containing papers presented at the geological conference. It includes six separate articles, of which the first, by W. S. Bayley, not unnaturally deals with the scientific contributions of the University itself, which are of no mean importance. The rest of the contributions are of wider scope and present useful summaries of the progress of various branches of geology in general throughout the period in question. The summaries of progress in petrology, oil geology, and ore-genesis are specially useful; the last two in particular are rarely regarded as worthy of such treatment in this country, owing to their economic bias. They all include excellent summaries of non-American work, and are by no means insular in tone. A little more attention to proof-correcting would have been of benefit; for example the present writer finds his name spelt in three different ways. But this is a minor blemish, and the work will be useful to geologists in countries other than America.

APPENDIX TO THE CATALOGUE OF METEORITES. By G. T. PRIOR. pp. 48. British Museum, 1927. Price 2*s*.

THOSE who already possess the catalogue of meteorites in the British Museum (Natural History), issued in 1923, may care to add to it the small publication, whose title is given above in an abbreviated form. It contains descriptions of new falls since 1922, and also of some older ones previously omitted, bringing the subject up to July, 1927.

REPORT ON THE PALAEONTOLOGY OF THE ZANZIBAR PROTECTORATE BASED MAINLY ON THE COLLECTION MADE BY G. M. STOCKLEY. 180 pp., 23 plates. Published by Government of Zanzibar. Crown Agents for the Colonies, 4 Millbank, S.W. 1, 1927. Price 21*s*.

SCATTERED along the eastern coast of Africa are a few outliers of Kainozoic sands and limestones, of which some are unfossiliferous, and some have yielded a few fossils of indefinite age. The correlation of these isolated deposits has been hitherto uncertain, but they can now be dated owing to the stratigraphical sequence well established on the collections described in this report. They were made by Mr. G. M. Stockley during the geological survey of the Zanzibar Protectorate in 1925–6, supplemented by specimens obtained by Dr. Wayland, Director of the Geological Survey of Uganda; some fossils earlier collected along the mainland are redescribed and discussed. The collections are described in five memoirs: On the foraminifera by Dr. A. Morley Davies, on the mollusca by Mr. L. R. Cox, on the echinoids by Mr. Stockley, on the crustacea by Dr. C. J. Stubblefield, and on the fish-teeth by Dr. E. I. White. This work is illustrated by twenty-three exceptionally clear photographic plates. The longest memoir is that on the mollusca by Mr. Cox, who contributes also an introductory statement on the stratigraphy of the Zanzibar Archipelago. The most important result is the discovery that Pemba includes some richly fossiliferous Lower Miocene limestones. Their foraminifera and mollusca show that they range from the Upper Aquitanian into the Burdigalian. The limestones are overlain by unfossiliferous variegated loams and sands, which being conformable are regarded as also Miocene. They resemble the Magarini Sands of Kenya Colony. Zanzibar Island includes a series of Pliocene beds, of which the lower series is rich in fossils and the upper or Mazindini Beds are unfossiliferous red loams and sands. They, Mr. Stockley suggests, may be the equivalent of the Mikindani Beds of Tanganyika Territory. Some Pleistocene beds, the Azanian limestones, form two main terraces along the coasts of both Zanzibar and Pemba. The Lower Azanian terrace is at 75 ft. above sea-level in Zanzibar and at 40 ft. in Pemba, indicating differential elevation of the area. At a low level along the coast occurs a shelly sandstone, which indicates a slight rise in recent times, followed by a later readvance of the sea.

Mr. Cox's careful description of the molluscs includes a review of the range of some of the more important species, such as *Ostrea virleti*, *Pecten vasili*, and *O. hyotis*; this statement enables the evidence of these fossils to be more definitely interpreted. Mr. Cox confirms the Miocene age of the limestones at Fundi Isa and the Pliocene age of crag-like beds at Mombasa.

Mr. Stockley describes a series of echinoids, and Dr. Stubblefield a new fossil crab from the Miocene beds of Pemba. The shark's teeth described by Dr. White are from the Pliocene and Pleistocene.

The Government of Zanzibar is to be congratulated on the publication of the results of its survey in a form that will make this report of permanent value as a work of reference to East African geologists. The islands did not promise much of special geological interest, but they prove to throw much important light on the later geological history of East Africa. The publication will be of great assistance to the surveys of other British Dominions in East Africa. The interest of the Report will also continually recall the existence of these limestones in Pemba, which may later prove of great commercial value.

J. W. G.

THE ELEMENTS OF ECONOMIC GEOLOGY. By J. W. GREGORY. pp. xiv + 312. London: Methuen & Co., 1927. Price 10*s*.

THIS book is intended to give in a condensed form a general view of the scope of economic geology. Its twenty-three chapters are divided into five principal sections: Introduction, Ore Deposits, Earthy Minerals, Engineering Geology, and Mineral Fields. The chapters devoted to ore deposits occupy nearly half the book, including also the larger part of the introduction. The author's views on the origin of ores are clearly and cogently expounded, but in reading them it is difficult to avoid the feeling that the style adopted savours a little too much of the controversial for so elementary a book. It is well known that the conception of a magmatic origin for ores is somewhat of a red rag to Professor Gregory, and much of this account may not unfairly be regarded as special pleading. It is possible that the idea of magmatic ores was a few years ago pushed too far, and the inevitable reaction is now due. Also to some extent the controversy in reality turns on questions of terminology. It is in point of fact impracticable to draw a hard and fast line between magmatic and hydrothermal processes, and from this fact much of the trouble arises. It is, however, refreshing to find an eminent British geologist concerning himself at all with what is really the most interesting part of petrology.

The section on earthy minerals deals with micas, asbestos, and gems, clay, building stones, and road-metal, cements, the soil, fertilizers, and salt deposits. All these sections are necessarily very brief and condensed, but many facts of great interest are quoted from the author's wide experience. The fourth part deals with water supply, coast defence, and land reclamation, and the economic side of seismology, with special reference to earthquake-resisting constructions. The last section gives in some 40 pages a condensed account of the geology of coal and oil.

In writing this book the author has set himself a difficult task. The field covered is so wide that in the limited space available it is almost impossible to avoid giving occasionally a somewhat one-sided view of certain matters as to which there is room for differences of opinion. A very brief and condensed statement must necessarily be rather dogmatic in tone. Furthermore, as to matters of fact, it would be possible to offer criticisms on many points of detail, but this is always an ungrateful task. The strongest point of the book is beyond doubt the impression that it gives that Professor Gregory has actually seen a large proportion of the things that he describes, and it differs in this respect from some other works, which though perhaps more strictly accurate in all points, yet lack the touch of a living personality.

R. H. R.

Monograph on the Triassic Flora of Bald Hill, Bacchus Marsh, Victoria. By F. Chapman. Mem. National Museum, Melbourne, No. 7. pp. 121–55, pls. x–xiii, and text-figure. 1927.

A DESCRIPTION, based on unsatisfactory material, of a flora of early Mesozoic aspect. From Mr. Chapman's descriptions and figures, it would seem that none of his specimens are sufficiently well preserved for specific determination. One new genus and five new species are erected.

T. H.

The Tinfields of Zaria and Kano Provinces. By C. Raeburn, A. D. N. Bain, and W. Russ.

Tinstone in Calabar District. By C. Raeburn.

Bulletin No. 11, Geological Survey of Nigeria. pp. 88, with maps, sections, and 6 plates. 1927. Price 10*s*.

THIS Bulletin, containing two memoirs, completes the preliminary account of the geology of the Nigerian tinfields. All known occurrences of tin have now been described, and it is clear that there are two sources of tinstone : the granites of the Younger Intrusive Series and some tourmaline-pegmatites of rather earlier date. Owing to administrative changes the well-known plateau is no longer in Bauchi Province, and in the text it is now described as the Nigerian Plateau.

The first part of the memoir consists of three sections, each complete in itself, describing different but contiguous areas, wherein the geological features all appear to be very similar : the Calabar area, however, lies far to the south. The tin deposits here do not appear to be of great importance. There is some monazite and apparently only a mere trace of gold.

REPORTS AND PROCEEDINGS.

Mineralogical Society.

10th January, 1928.

Dr. L. J. Spencer : " Potarite, a new mineral discovered by the late Sir John Harrison in British Guiana."

Small nuggets and grains of a brittle white metal have been found very sparingly by diamond-washers in the neighbourhood of the Kaieteur Falls on the Potaro River. This mineral, previously erroneously described as " allopalladium ", was proved by Harrison to be a compound of palladium and mercury, PdHg, with a density (15·0–16·1) considerably higher than that of either of the component metals. There is a crystalline structure which on the surface of one nugget is shown as indistinct cubic octahedra. The original " allopalladium " from the Harz Mountains, supposed to be a hexagonal modification of palladium, could not be procured for a re-examination ; it is probably the ordinary cubic palladium.

Dr. H. V. Ellsworth : " A simple and accurate Constant-volume Pyknometer for Specific Gravity Determination."

The pyknometer of 10 c.c. capacity is made of silica glass, thus possessing several advantages over one made of ordinary glass. The stopper is perforated by a capillary and is continued into a graduated side-tube, which dips under water while the apparatus is cooling. The volume of the contained water to the graduations on the side-tube can be readily and accurately determined to 0·0002 c.c.

Mr. W. Campbell Smith : " The Optical Orientation of Labradorite from County Down (Ireland) determined by the Fedorov Method."

The labradorite from basaltic dykes at St. John's Point, Ardglass, Co. Down, of which the chemical composition and refractive indices were published in 1912, has been studied by the Fedorov method and the optical orientation determined.

Dr. C. E. Tilley demonstrated the inversion of Ca_2SiO_4 in a metamorphic limestone from Larne, Co. Antrim (Ireland), and Mr. A. F. Hallimond exhibited an electro-magnetic separator for mineral powders.

CORRESPONDENCE.

Sir,—I regret that in my article in the October number of the Geological Magazine I should have used an expression which was liable to be misunderstood. I wrote that : " F. Loewinson-Lessing claims to have put forward a classification . . . in 1890." I wish to make it clear that I had no idea of disparaging Professor Loewinson-Lessing's work, or of questioning his priority in the matter. My reason for using this particular form of expression was that Professor Loewinson-Lessing's original papers were not accessible to me, and my only source of information was a note that appeared recently in *Mineral Abstracts.* I have the greatest difficulty in obtaining access to petrological literature, especially to volumes more than twenty-five years old. This is the explanation, and I hope it may be accepted as the excuse, of many faults of omission in my writings. As regards the question of priority, I have already pointed out that Ferdinand Zirkel has priority over all of us in recognizing the importance of the saturation principle in the classification of eruptive rocks.

S. J. Shand.

Stellenbosch, South Africa.
20th January, 1928.